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"RECREATIONS" IN SECONDARY MATHEMATICS.

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The Pedagogic Value of Recreations.

The question of *interest* is the foundation of all true pedagogic methods. A good teacher seeks to secure the attention of his students by presenting the subject they are studying in an attractive form, and to instill its principles if possible by processes agreeable to the student.

It used to be he thought that a draught of medicine to be effective must be unpalatable, but fortunately that day is past in the practice of medicine. It is equally true that the day has gone by in which arithmetic and algebra are to be regarded as bitter pills to be reluctantly swallowed, if one would not have them hypodermically injected through the medium of a birch rod.

The need of arousing and holding the student's interest is recognized by all wide-awake teachers of the present day. There are indeed some teachers who are willing that their students should be not only interested but even *entertained,* if through such entertainment, the real work of the classroom can be advanced. The newer textbooks in arithmetic, algebra and geometry in response to this demand, are beginning to include more or less material that may properly be classed as recreational.

I am not sure but that this is one of the functions of the real or practical problem about which we hear so much lately. For example, problems in the measurement of heights or distances, particularly if done with homemade instruments, have their value more in the fact that they appeal to the spirit of play in the student than for any practical use that he will ever make of such devices. Have we not in the use of such material an exemplification of the method of Froebel of "Learning through play"? In playing at being practical in the school-

room, the student is absorbing in an easy and agreeable way certain mathematical facts and processes which will later be or real value to him in his life-work.

This is of course but a small part of the argument for practical mathematics; and similarly, it is only a part of the argument for Mathematical Recreations, that by their use we may stimulate the interest of our students and brighten the serious business of our teaching.

The purpose of this article is to suggest various forms of Mathematical Recreation suitable for secondary students, and to point out that they may be employed in our teaching as legitimately as much of the material we are now using, and perhaps more agreeably, to vitalize the subject of mathematics, and show its connection with the ordinary affairs of life, to sharpen the mental faculties of our students, to stir their imaginations, and perhaps to arouse in them an increased appreciation of the power, the beauty, and the universality of mathematics.

History.

The use of Mathematical Recreations as a device for arousing interest is not a new idea. The puzzles and catch questions of the old arithmetics, the hare and hound problems of the algebras, are examples of this sort. The human mind has always found pleasure in puzzles, tricks, and curiosities of all sorts. This curious propensity is not peculiar to any race, nor any period of history, it is simply innate in every man and every child.

We have no less an authority than Cantor for attributing the first mathematical puzzle to the Ahmes papyrus (2000 B. C.).[1] The problem of the fox, the goose and the peck of corn, and how to get them across the river was known to Alcuin in the time of Charlemagne, about 800 B. C.[2] The hare and hound problem appears in an Italian arithmetic of 1460.[3] Magic squares were known to the Arabs and perhaps to the Hindus[4]; there is a record of one in a Chinese book of the date of 1125.[5]

Most of the puzzles of the present day, whether of a mathematical nature or of a general character such as are found in the columns of the daily papers have come down to us from

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[1]Cajori, *History of Elem. Math.* P. 24.
[2]Cajori, P. 220.
[3]Smith, *Rara Arithmetica.* P. 465.
[4] Ball. *Recreations.* P. 130.
[5] Carus. *Chinese Philosophy.* P. 19.

a much earlier time. The modern puzzle, like the modern joke, has its roots deep in the past.

Toward the close of the sixteenth century the interest in Mathematical Recreations seems to have become quite general among the mathematically inclined. Perhaps it was that the keener mathematical minds of that day soon exhausted the store of mathematical knowledge of the time; analytic geometry and the calculus had not yet been invented; the eager student was weary perhaps of the scholastic subtleties of the preceding years, the application of mathematics to practical affairs had been little developed, and so he turned his attention to the investigation of curiosities and puzzling questions of various kinds, and found there an outlet for his restless energies.

It was about this time that questions of this sort began to appear in the textbooks. In an arithmetic published in Nürnberg in 1587 we find a chapter devoted to Recreations,[6] and such material became quite common in the English and German textbooks of the next century.[7]

In 1612 appeared the first extensive compilation of Mathematical Recreations. This was the well known *Problèmes plaisans et delectables* by Bachet de Méziriac. It is a collection of famous or historic problems, of numerical tricks, puzzles, and games. Some of these are from previous collections like Alcuin's of the eighth century, some from the writings of Cardan, Tartaglia and the mathematicians of the preceding century, and possibly others are from oriental sources,[8] for both the Hindus and Arabs were given to speculations of this sort. This book may be obtained in a modern edition.—(See bibliography at the end of this article.)

The next collection of importance was Ozanam's *Récréations Mathématiques*, published first in 1694. There were many later editions, with additions by Montucla and others. The last edition is a translation by Hutton, published in London, 1840, and now out of print. This volume contains material similar to that of Bachet, and additional chapters on curious properties of numbers and the number system; curiosities in progressions, permutations, and probabilities; magic squares; and tricks, puzzles, and problems from geometry.

These two books are the sources of most of the problems of

[6] Smith. *Rara Arithmetica.* P. 391.
[7] Cajori. P. 222.
[8] Ball. *Mathematical Recreations.* P. 2.

this kind to be found in the collections of Mathematical Recreations of the present day like Ball's *Recreations,* White's *Scrap-book* and Jones' *Mathematical Wrinkles.*[9] Professor Ball in his preface, written in 1892, says, "I believe it would be difficult to find in any of the books current in England on mathematical amusements as many as a dozen puzzles which are not contained in one of these volumes." The same thing is either avowedly, or obviously, true of the modern French compilations, like those of Lucas, Vinot, Fourrey,[10] although these contain in addition certain types of mathematical curiosities that have originated since the days of Bachet and Ozanam.

The best collection of the more modern contributions to the subject of Mathematical Recreations is a German book, *Mathematische Unterhaltungen und Spiele* by Ahrens, published by Teubner, Leipzig, 1901.

As I have already intimated, mathematicians of the sixteenth and seventeenth centuries seemed to find an especial delight in the pursuit of questions which were a little outside the range of pure mathematics, and this interest was not confined to the student or beginner merely, but was shared by the greatest minds of the time. Among the master minds of those years whom we find devoting themselves, in part at least, to Recreations of one kind or another, may be mentioned Tartaglia and Cardan in the sixteenth century, and Kepler, Pascal, Fermat and Leibnitz in the seventeenth century.

May we not believe that besides the pleasure derived by these masters in the pursuit of mathematical recreations, that they received also a stimulus and a training that enabled them to make serious contributions to mathematical knowledge? The algebraic solution of the cubic equation appears to have been the direct outcome of researches undertaken in the beginning in a spirit of sport. You will remember the famous problem solving contest indulged in by Tartaglia and Floridus in 1540.[11] Again, the researches of Pascal and of Fermat in the theory of probability seem to have originated in a gambling problem, proposed by a certain noble gamester to Pascal, who communicated it to Fermat. After answering the gamester's question, Pascal then proceeded to consider the general case and the mathematical theory of probability was born.[12]

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[9] See bibliography.
[10] See bibliography.
[11] Cajori, P. 226.
[12] Ball's History, P. 294.

An enthusiastic witness of the esteem in which the Mathematical Recreation was held during the seventeenth century may be found in the preface of Leybourn's *Pleasure With Profit* published in London in 1693. This is the first important collection of Mathematical Recreations published in the English language. In this curious old book the author, who is evidently an enthusiast, devotes several pages of his preface to showing that mathematics affords recreations to be preferred to all the other pleasures and sports of his age, such as hunting, angling, fowling, shooting with the long bow, tilting, wrestling, and so on. His book is dedicated to "Ingenious Spirits to induce them to make further scrutiny into this Sublime Science, and to divert them from following such vices, to which Youth in this Age are so much inclined."

During the last two centuries mathematical curiosities of various kinds, some old and some new, have continued to attract the attention of mathematicians. Among those who have devoted a part of their attention to such studies may be mentioned Euler, Monge, Lagrange, Hamilton, Horner, De Morgan, and in more recent years, Sylvester, Klein, Cayley, Cantor, Tait, Dodgson, Pierce and Newcomb. There are also many who have written quite extensively on the general subject of Recreations, some of whom are mentioned in the bibliography accompanying this article.

During these later years there have been many interesting additions to the questions that may properly be classed as Recreations, such as the Circle and Its Triangles, Unicursal Paths, Paper Folding, most of these later additions being connected with geometry, as the earlier ones were with arithmetic and algebra.

It is only recently, too, that we have had complete published accounts of certain interesting subjects connected with the history of mathematics, and discussions of such questions as number systems and symbols and numeration.

Within the last fifty years, more or less, an entire new field has been opened to the student of Recreations in the developments of such phases of mathematics as the non-Euclidean geometry, fourth dimension, hyperspaces and the foundations of geometry . Such subjects are, of course, important branches of mathematics, and associated with them are the names of some of the greatest mathematicians of their time, who have pursued their researches in the strictest spirit of serious math-

ematical investigation. It is hardly accurate to class such subjects as Recreations, and yet they may be regarded as affording material for recreations on account of their unusualness and their fascination for the inquiring student.

We have seen that Mathematical Recreations are almost as old as mathematics itself, that through all the centuries they have proved a source of pleasure as well as profit to student and master alike. In the light of their history we can hardly regard such phases of mathematics as too trivial for the student of today.

Methods of Using Recreations.

The study of Recreations is recommended as a diversion to all teachers of secondary mathematics even if they do not feel that they can introduce such material into their instruction.

For teachers who may care to use this means of imparting a human touch, as it were, to their teaching, several methods are available, among which may be mentioned:

The Mathematics Club. The possibility of a mathematics club among high school students is proved by the number of successful clubs now in existence in high schools and academies in all parts of the country. Most of these clubs have evening meetings which are devoted to reports prepared by the student members under the teacher's direction.

The Club at Shattuck School, organized by the writer in 1903, was so far as he knows, the first one in this country in a school of secondary grade. Those who may be interested can find an account of this club, its methods of work, and the subjects considered, in School Science and Mathematics, Vol. V, P. 323, also Vol. XI, P. 500.[13]

Informal Meetings devoted to games, puzzles, tricks for which no special preparation need be made, nor formal reports presented.

These informal or occasional meetings might be devoted to talks or lectures by the teacher, on a great variety of subjects, such as number systems, or the fourth dimension, to mention only two. Such talks could be given before the whole school in the evening, or before the class during part or all of a recitation period.

Assigned Readings with papers or essays based on this reading. It may be possible to induce the teacher of English to accept daily or monthly themes on subjects related to

[13] Also in *The Educational Review*, May, 1905. Vol. 29, P. 515.

mathematics. The mathematics teacher could direct the students' reading and perhaps suggest the method of treatment. Good subjects would be squaring the circle, the beginnings of counting, or any historical topic. If one of the girls would like to write an original narrative with a mathematical flavor, let her try a fanciful story like, "The Adventures of *X*" in a recent number of the *Open Court Magazine*, or like Grace Ward Calhoun's, *In Algebra Land*,[14] or Leacock's *Adventures of A, B, and C*.[14]

Debates. If there is a debating team in the school, what better subject can be found than the question of the duodecimal *vs.* the decimal number system, or "Resolved: that the metric system should be immediately introduced by law in this country."

In the Class Room. Some textbooks include fallacies, curious problems, puzzles, historical notes, which may be made a part of the regular assignment for study. Other questions of the same sort may be proposed by the teacher for immediate consideration or dictated for the next day's work. If there is a mathematical library in the class room, references may be made to various titles for individual reports later. Or a question may be discussed informally whenever it suggests itself in the day's work. Some subjects may be worth but a passing notice, as for example, in connection with the study of the regular polyedra it would be interesting merely to show the pictures of star polyedrons,[15] or to refer to Kepler's curious theory of the universe based on the five regular polyedra[16]; other subjects may be worth dwelling upon at greater length.

The wide-awake teacher who is somewhat familiar with the literature of Recreations will find many opportunities of introducing them in this incidental way to the great advantage of his teaching and the enjoyment of his students.

Definition of a Mathematical Recreation.

The term Mathematical Recreation as here used is understood to embrace any subject with a mathematical bearing or basis which has an ***intrinsic interest***, a possible value in mathematics teaching, and which is ***not included in the traditional courses***.

The term Byways of Mathematics would perhaps more

14 See bibliography, and note 19.
15 Lucas. *Récréation Mathématiques*, Vol. II. P. 206.
16 Cajori. *History of Elementary Mathematics*. P. 249.

nearly express this meaning, but I use the word Recreation because that is the familiar generic name for all of this unclassified material.

Such a definition permits us to include subjects from the history of mathematics, and surely no argument will be necessary in defense of such an interpretation. Certain chapters from the history of mathematics as, for example, the chapter on Greek geometry are almost a necessary part of a liberal education. It has been said that "No subject loses more than mathematics in any attempt to dissociate it from its history"; and according to Cajori, "The history of mathematics affords the best means of tracing the line of intellectual development through the ages."

An important part of the study of English consists in tracing the gradual growth of the English language, and surely a knowledge of the constitution and development of our number system has a significance for us, second only to such information concerning our language.

For the above reasons, and because such questions are not provided for in our traditional courses, and because of their undoubted interest to students, certain topics from the history of mathematics are here included under the head of Recreations.

Possible Material.

It is not likely that any teacher can, nor will he care to, avail himself of all the material that may be included under the comprehensive definition I have given above of Mathematical Recreations. I have felt, however, that if suggestions as to possible topics are to be made at all, such suggestions should be fairly complete and at the same time specific.

For this reason the following list of topics is given, all of which I have tried at one time or another, by means of one or the other of the above methods and have found either interesting or instructive or both. I have tried to indicate briefly the purpose, or special value of some of the topics.

Recreations With Numbers.

Some of these will be suitable for classes in arithmetic, others will be better adapted to more mature pupils.

Numerical *Puzzles.* Perplexing Questions, Tricks, Guessing Numbers, Etc. (To be used as in mediaeval times for "Sharpening the Wits.")

Famous or Historic Problems. (To add interest and variety.)

Mathematical Games. Three in a Row, Games with Counters, Card Tricks. (Chiefly for fun.)

Trick Additions, Trick Multiplication, Mental Cube Root, Etc. Prodigies. (Both amusing and instructive.)

Fallacies and Catch Questions. (To give mental alertness.)

Short Cuts. Squares and Products of Certain Numbers, Divisibility. (For their practical value.)

Mystic Properties of Numbers, Luck in Odd Numbers, Fatality of Certain Numbers, for example 13, Sacredness of 3 and 7, Myths concerning Numbers. (As curiosities, and for the sake of the historic and literary interest.)

Curious Properties of Numbers. The Numbers 9, 11, 35, 142857, The Ten Digits, Perfect Numbers, Amicable Numbers, Triangular and Figurate Numbers, Right Triangular Numbers, Prime Numbers and Eratosthenes' Sieve. Fermat's Last Theorem. (All these as curiosities and for the insight they give into numerical relations.)

Numerical Curiosities. Magic Squares, Pascal's Triangle, Combinations of the Ten Digits. (For the same reasons as in the preceding.)

Number Forms. (See if any of your students have a *mental picture* of the sequence of the numbers from 1-20 or 1-100. There may be some interesting results.)

Time and Its Measurement. Calendars. (Good for abstract thinking.)

First Notions of Number. The Beginning of Counting, Do Animals Count?

Origin of Our Decimal System. Due to Our Ten Fingers. Use of Counters.

Numeration. Origin of Names for Numbers.

Primitive Number Systems. Based on Five, on Twenty.

Other Number Bases. Twelve, Two, Sixty.

(The last five topics for the sake of the general cultural value of the information.)

The Positional Idea in Our Number System. Invention of the symbol for Zero, Importance of the Zero. (To show the completeness, the beauty, and simplicity of our decimal positional number system.)

History of Our Hindu or Arabic Number Symbols. (Showing the gradual development of the present symbols.)

NUMBER SYMBOLS OF THE ANCIENT EGYPTIANS, CHALDEANS, GREEKS, ROMANS. (It is a good exercise to have the student write a given number in the symbols of each system.)

USE OF THE ABACUS BY THE GREEKS AND ROMANS. How Used and Why Necessary?

MEDIAEVAL METHODS IN ARITHMETIC. (The last four topics have a mathematical value as well as an historic interest.)

CHAPTERS FROM THE HISTORY OF ARITHMETIC. The Unit Fraction of Ahmes. The Theory of Numbers among the Greeks, The Hindus, The Arabs, Decimal Fractions, Logarithms, Weights and Measures, Etc.

RECREATIONS IN ELEMENTARY ALGEBRA.

THE FAMOUS PROBLEMS (from the mediaeval and later collections.) (As in arithmetic for interest and variety.)

PUZZLES, GAMES, TRICKS. (As in Arithmetic except that those will be used which have an algebraic basis. Certain of them illustrate the significance of our method of writing numbers of two or more digits.)

ALGEBRAIC FALLACIES. To prove $1 = 2$, $1 = 0$, $1 = -1$, Any Number=Any Other Number, Etc. (These point out the necessity for care in the use of algebraic processes.)

HISTORY OF THE SIGNS OF OPERATION. (This topic would show the various devices used at different times to denote $\times$, $+$, $=$, etc. The date of the adoption of the present sign.)

DEVELOPMENT OF ALGEBAIC SYMBOLISM. (This is an historical topic of great value and significance. An instructive exercise is to have a given expression or equation written in the symbols current at various time from Diophantus to the present day. This can not fail to arouse an appreciation of the wonderful convenience and simplicity of the present highly developed symbolism of algebra.)

LARGE NUMBERS. (All students are fascinated by large numbers, and they serve a valuable purpose in stretching the youthful imagination. They arise in the study of progressions as in the "Grains of Wheat on a Chess Board" and in permutations as in the number of hands possible in a game of whist. Calculations may be made by logarithms. A few good examples are, "How many ancestors did you have in the time of Charlemagne, and how was this possible when Europe did not contain one ten thousandth part of that number of people? How much would 1 cent placed at compound interest, at 4%, at the

time of Christ amount to now? Answer, 84 spheres of solid gold as large as the earth. How accurate is the value of π to 100 decimal places? How large is the number 9^{9^9}? How long would it take to count it? How many books to print it?)

Games of Chance. Systems at Monte Carlo, Probability Curves. This is another subject of perennial interest, at least to boys. After a study of permutations, two or three lessons is time enough in which to teach the elements of the theory of probability. One rather unusual application of the theory of probability is to apply it to the calculation of π as follows: If a stick of length l be dropped on a table ruled with parallel lines at a distance a, $(l < a)$, the chance that it will fall across one of the lines is $\frac{2l}{\pi a}$. The probability can be determined by actual trial, and if the number of cases is large enough, a fairly close approximation can be obtained.[17]

Chapters from the History of Algebra. The Beginnings of Algebra, Origin of the Name Algebra, First use of x.

The Number Systems of Algebra. Fractions, Irrationals, Imaginaries.

Recreations in Geometry.

The opportunities for the use of Recreations in geometry are almost unlimited. I shall merely mention the more obvious classes, and explain with a minimum of detail some that may not be quite so familiar.

Chapters from the History of Geometry. The Egyptian Rope Stretchers, The Pythagoreans, Euclid and his Immortal Elements, Etc.

Famous Problems of Geometry. Squaring the Circle, The Trisection of an Angle, Duplication of the Cube, Regular Polygons.

Famous Theorems of Geometry. Archimedes' Cylinder and Sphere, Hero's Triangle, Pons Asinorum, Euler's Theorem, Feurbach's Theorem.

Puzzles, Tricks, Games.

Problems on a Chess Board. The Knight's Move, The Eight Queens.

Good Luck Smybols. The Swastika, The Monad, The Cross, The Greek Cross.

Paper Folding.

Measuring Instruments. (Including the Mediaeval devices

[17] De Morgan. *Budget of Paradoxes.* P. 171.

for measuring heights and distances, as well as the modern transit, sextant, range finder, etc.)

MENSURATION of Irregular or Unusual Areas and Solids. (For example a barrel, an anchor ring, the flow of a river.) Application of Simpson's Rule, the Prismoidal Formula, etc.

MATHEMATICAL MACHINES. Planimeter, Pantograph, Slide Rule, Linkage for Drawing a Straight Line, Other Linkages, Devices for Drawing Ellipses, Parabolas, Etc.

HIGHER PLANE CURVES. Spirals, Involutes, Cycloids. (Their use in mechanics as the curves of cams, gears, parabolic reflectors.) Also the Cissoid, Conchoid and the Conics as devices for squaring the circle, trisecting an angle, etc.

THE MATHEMATICS OF COMMON THINGS. The Watch as a Compass, Sun Dials, The Carpenter's Square, Telescope, Compound Mirrors, Maps in Various Projections, The Four Color Theorem, A New System of Planting Corn, Land Descriptions, Etc.

OPTICAL ILLUSIONS. Familiar Examples, How We See Solids, Illusions in Greek Architecture.

UNICURSAL PATHS. Mazes, Rules for Threading a Maze, Euler's Problem of the Seven Bridges, The Hamilton Game.

CURIOSITIES. Star Polyhedrons, Tile Floor Patterns, Paradromic Surfaces.

PARADOXES. Perpetual Motion, Curve on a Baseball, English on a Billiard Ball, Sailing Faster than the Wind, Why a Machine May Not be as Strong as its Model, Etc.

MATHEMATICAL SYMMETRY IN NATURE. (Symmetrical forms in plants, leaves, honeycomb, starfish, snowflakes, crystals, etc.)

MATHEMATICAL SYMMETRY IN ART. (Use of geometric forms in design, in architecture, etc.)

FALLACIES. (Besides the commoner ones, "To prove every triangle isosceles," etc., there are good examples which involve the idea of limits; E. g., To prove the circumference of a circle equal to its diameter.[18] It is also a good exercise in clear reasoning to propound fallacies of a more general sort, where the error lies in the reasoning and not in the figure. They may be found in any text on logic.)

THE HUMAN SIDE OF MATHEMATICS. Pictures of Mathematicians, Epigrams, Epitaphs, Anecdotes.

THE LOGICAL SYLLOGISM. (Considered as the perfect form of all deductive reasoning. Throw into this form the reasoning

[18] Fourrey, *Curiosités Géométriques*. P. 149.

"Angle A=Angle B being base angles of an isosceles triangle"; or express as a sequence of three or more complete syllogisms the proof of the fact that "Supplements of equal angles are equal"; or write premises for the conclusion "Angle B equals angle A." A great variety of exercises of this sort is possible. The students enjoy the work and its value is unquestionable.)

FOUNDATIONS OF GEOMETRY. (Exercises like the following are possible: Criticize the following definitions, "A straight line is one that extends everywhere in the same direction," "A circular cylinder is a cylinder whose *base* is a circle," "A square is a rectangle *all* of whose sides are equal.")

Axioms: Nature of an Axiom, Postulate, Euclid's List, Other Lists. (Point out unconscious assumptions in your text. Try to make a minimum list, etc.)

If this subject proves too deep for your students refer them for refreshment to Leacock's List of Assumptions for a Boarding House Geometry.[19]

NON-EUCLIDEAN GEOMETRY. (Easy to introduce after spherical geometry somewhat as follows. Suppose AB, cutting CD far to the left, to revolve about point P on AB. There are three possibilities. (1) After failing to cut CD to the left AB immediately intersects to the right. (2) It intersects for an instant in both directions. (3) An appreciable time elapses between the intersections to the left and to the right. These three hypotheses lead to the three geometries:

(1) One parallel to a line through a point. Euclid. The plane.

(2) Two parallels to a line through a point. Lobatchewsky. The pseudospherical surface.

(3) No parallels to a line through a point, Riemann, the spherical surface.

Can experience or our senses tell us which is the correct geometry of space? If not we may assume any one of the three and base a geometry upon it. The Three Geometries (List some of the theorm of each History of the Parallel Postulate. Attempts to prove it. Substitutes, etc., etc.)

THE FOURTH DIMENSION. This subject comes up naturally in solid geometry in connection with symmetrical spherical triangles, or symmetrical tetrahedrons and the attempt to superpose them. A conception of the fourth dimension, or at least the logical possibility of it is not at all beyond the powers of a secondary stu-

19 Leacock, *Literary Lapses*. P. 26.

dent. Begin with a space of one dimension, add dimensions, and reason by analogy. Discuss the miraculous power we would have in a two-space and from this argue what would be possible for a four-dimensional being in our space. Consider the hypercube, how made up, and why impossible for us to imagine it—the model in three space of a hypercube, is like a drawing of a cube on a blackboard.

After a little study of the subject there is a chance to stimulate some original thinking by suggesting questions like the following.

(1) Describe life in a world of two dimensions like "Flatland" but in a *vertical* plane.

(2) Describe the projection and the development of a hyper-tetrahedron in our three-space.

(3) Invent a substitute for a pulley in a vertical plane land.

(4) What freedom of motion is possible to wheeled vehicles in a four space?

(5) Elaborate the idea that heaven may lie in the direction of the fourth dimension.

Space and Hyper Spaces. Infinity. (Considerations like those of the last two topics give a valuable training in space conceptions. Other space questions worth propounding though perhaps they may not be answered are "What is the extent of our universe? Of space? Is space bounded? If so what lies beyond? Is it continuous? Is it homogeneous? Is it planar or curved? The idea of curved space is a fascinating one. It connects naturally with the fourth dimension and non-Euclidean geometry. One can argue to it easily by analogy from the curved line and the curved surface. The logical conclusion is a space that is boundless but not infinite, a space in which a straight line extended returns to its starting point.

Conclusion.

Topics like the last three or four may seem too abstract and too difficult for high-school boys and girls; but I can assure you that the elementary notions, simply presented, are not at all beyond their comprehension. Such questions arouse the imagination, give a breadth of view, and a grasp of logical methods not attainable through a mere study of the textbook. Besides their intrinsic value and interest, they serve as a striking example of the power of mathematical reasoning to carry us into fields beyond the reach of our senses.

It is only the older students of course who are able to ap-

preciate the significance of questions of this kind. The students of the first and second high-school years enjoy the puzzles, tricks, fallacies, curiosities, and even the historical topics, but it is with the older students that one may be most successful in arousing a love of mathematics for its own sake, an appreciation of its beauties, and the all-pervading extent of its applications.

I have already spoken of the beauties that may be discovered in the symbolism of algebra, and the wonderful perfectness of the decimal positional number system, and I have hinted that mathematics may fairly be considered a factor in our aesthetic development, when one reflects upon the extent to which mathematical symmetry underlies so many of the beautiful forms of nature and of art. Such considerations might well transfer these subjects from the field of Recreations to a recognized place in the legitimate courses.

If a student is led into the byways of Mathematics through a pursuit of some of the varied Recreations listed above, he can not help but be impressed with the universality of mathematics. He will find that mathematical laws prevail not only in the practical affairs of the world, as he learns in his textbook, but also in the most unexpected situations and relations of life.

An impressive conclusion for the year's work of a Mathematics Club would be an evening devoted to considering the possibility of "A World Without Mathematics." Let the members come prepared with suggestions as to what would happen in the business and industrial world, what changes would be necessary in our manner of living and methods of thinking, how far reaching would be the effects, if all knowledge of mathematics were suddenly erased from the minds of men.

Bibliography, Selected.

This list contains only such books as are known to the writer to contain a popular presentation that can be understood by a high-school boy or girl, except that at the end are added a few selected titles, in addition, that may be of value to teachers. Additional references to the general subject of Recreations may be found in White's *Scrap Book* (87 titles), Lucas' *Récréations Mathématiques* (189 tit'es), and Ahren's *Mathematische Unterhaltungen und Spiele* (330 titles). Bibliographies on special subjects may be found in Fourrey's *Curiosités Géométriques*, Young's *Teaching of Mathematics*, Manning's *Fourth Dimension*, Wither's *Parallel Postulate*. Material may also be found in engineers' handbooks, encyclopedias, textbooks on astronomy, logic, surveying and books on practical mathematics.

Cajori, *History of Elementary Mathematics*, $1.50, The Macmillan Co.

Ball, *History of Mathematics*, $3.25, the Macmillan Co.

Rupert, *Famous Problems of Geometry* (4 pamphlets), D. C. Heath & Co. $0.10 each.

Fine, *The Number System of Algebra*, $1.00, D. C. Heath & Co.

Young, *The Teaching of Elementary Mathematics,* $1.50, Longmans, Green & Co.
Smith, *The Teaching of Geometry,* $1.25, Ginn & Co.
Jackson, *Sixteenth Century Arithmetic,* $2.00, Columbia University.
Frankland, *The Story of Euclid,* 1s., Newnes.
Smith, *Euclid, His Life and System,* $1.25, Chas. Scribner's Sons.
Manning, *Non-Euclidean Geometry,* $0.75, Ginn & Co.
Manning, *Fourth Dimension,* $1.50, Munn & Co.
Abbott, *Flatland,* $0.75, Little, Brown & Co.
Ball, *Mathematical Recreations,* $2.75, the Macmillan Co.
Schubert, *Mathematical Essays,* $0.75, Open Court Pub. Co.
White, *A Scrapbook of Elementary Mathematics,* $1.00, Open Court Pub. Co.
Jones, *Mathematical Wrinkles,* $1.65, S. I. Jones, Gunter, Texas.
Lloyd, *Cyclopedia of 5000 Puzzles,* $3.00, Lamb Pub. Co.
Dudeny, *Canterbury Puzzles,* $1.25, E. P. Dutton & Co.
Hampson, *Paradoxes of Nature and Science,* $1.50, E. P. Dutton & Co.
Brooks, *Philosophy of Arithmetic,* $2.50 (about), Normal Pub. Co.
Conant, *The Number Concept,* $2.00, the Macmillan Co.
Calhoun, *In Algebra Land* (pamphlet), Educational Gazette, Syracuse, N. Y.
Morris, *Geometrical Drawing for Art Students,* 2s., Longmans, Green & Co.
Sykes, *Source Book for Geometry,* $2.50, Allyn & Bacon.
Row, *Paper Folding,* $1.00, Open Court Pub. Co.
Fair, *The Steel Square,* $0.50, Industrial Pub. Co.
Kempe, *How to Draw a Straight Line,* $1.00 (about), the Macmillan Co.
Bruce, *The Circle and Its Triangles* (pamphlet), D. C. Heath & Co. $0.10.
Smith, *The Hindu-Arabic Numerals,* $1.25, Ginn & Co.
Moritz, *Memorabilia Mathematica,* $3.00, the Macmillan Co.
Pictures of Mathematicians, Open Court Pub. Co.
Klein, *Famous Problems of Geometry,* $0.50, Ginn & Co.
Smith, *Rara Mathematica,* $4.50, Ginn & Co.
Hilbert, *The Foundations of Geometry,* $1.00, Open Court Co.
Young, *The Fundamental Concepts of Algebra and Geometry,* $1.60, The Macmillan Co.
Young, *Monographs on Modern Mathematics,* $3.00, Longmans, Green & Co.
Heath, *The Thirteen Books of Euclid,* 3 vol., $13.50, Cambridge Univ. Press.
Withers, *Euclid's Parallel Postulate,* $1.25, Open Court Pub. Co.
Hinton, *Scientific Romances,* Swan Sonnenschein & Co.
Bachet, *Problémes plaisant et délectables,* $0.70, Gauthier-Villars.
Lucas, *Récréations Mathématiques,* 4 vol., $1.50 each, Gauthier-Villars.
Fourrey, *Curiosités Geométriques,* $1.00, Vuibert.
Ahrens, *Mathematische Unterhaltungen und Spiele,* M., 7.50, Teubner.
Evans, *Evolutionary Ethics and Animal Psychology,* $3.00, Appleton & Co.
Halsted, *Mensuration,* $1.25, Ginn & Co.
Thorndike, *Mental and Social Measurements,* $1.50, Science Press, N. Y.

MAGAZINE ARTICLES.

Excellent popular accounts on many subjects will be found in magazine articles. A few are listed below. The abbreviations used are: Popular Science Monthly (Pop. Sci.); Scientific American (Sci. Am.); SCHOOL SCIENCE AND MATHEMATICS (Sch. Sci.); The Open Court (Open Court); Archaeological Journal (Arch. Jour.); American Mathematical Monthly (Am. Math.); Messenger of Mathematics (Mess. Math.).

History of Arithmetic, Education, xxi-No. 3; Pop. Sci., xvi-No. 11.
Number Curiosities, Sci. Am. lxix-No. 1791, lvi-No. 1435; Sch. Sci. xiv-451; Open Court, xii-No. 10.

Games and Tricks, Sch. Sci. xii-828; xiii-819, xiv-229.
Mysticism of Numbers, Pop. Sci. xxv-4.
Number Symbols, Sci. Am. xxxiv-No. 5.
Number Systems, Pop. Sci. xi-No. 4; Am. Math. xxi-No. 9; Open Court vi-No. 47.
Duodecimal System, Sci. Am. xlviii-No. 1227; Sch. Sci. ix-516, 555.
Beginnings of Mathematics, Sci. Am. xxx-No. 772; Sch. Sci. v-385, 567.
Number Forms, Pop. Sci. xlii-No. 4.
Mental Calculations, Sch. Sci. xiv-71, xv-20.
Algebraic Fallacies, Open Court, xx-No. 3, xxi-No. 1.
Algebraic Symbols, Sch. Sci. ix-375; vii-406.
Right Triangular Numbers, Sch. Sci. x-683, xi-293, xiii-320.
Geometry in Practical Life, Nature, No. 43, P. 273.
Fourth Dimension, Sch. Sci. x-No. 43; Harper's Mo., No. 620.
Old Measuring Instruments, Sch. Sci., x-48, 126; Sci. Am. C1-No. 1.
Squaring Circle, Mess. Math., Vol. II, Vol. III.
Trisecting Triangle, Sci. Am. xxi, xxxviii; Sch. Sci. vi-358, 395, xiii-546.
Duplication of Cube, Sch. Sci. xiii-311.
Pythagorean Theorem, Sch. Sci. x-550, xiii-819.
Optical Illusions, Sch. Sci. xiv-190; St. Nicholas.
Mathematical Symmetry, Monist, xi-No. 1,
Hyperspace, Infinity, Pop. Astron. vi-No. 7; Littel's Living Age, No. 1875; Sch. Sci. xiii-715.
Flatland—A Play, Sch. Sci. xiv-583.
The Abacus, Sci. Am. lxix-No. 1791; Sch. Sci. vii-601.
The Sun Dial, Sch. Sci. viii-561.
The Swastika, Open Court, xvi-Nos. 3-6.
Labyrinths, Arch. Jour. xv-216.
Animal Counting, Nature, xxxiii-45.
Adventures of x, Open Court, Dec., 1914.
Map Constructions, Sch. Sci. v-29.
Geometrical Incongruities, Sch. Sci. viii-294, 250.

The writer will be glad to receive additional references, or suggestions for other subjects of study.

NEW GYMNASIUM FOR WOMEN.

The Board of Trustees of the University of Chicago has let the contracts for the construction of Ida Noyes Hall, the building which is to serve the women students of the University as Bartlett Gymnasium and the Reynolds Club provide for the physical culture and social needs of the men. The new hall will be a notable addition to the group of nearly forty buildings which have now been erected on the University quadrangles. This latest building, which a generous gift of Mr. La Verne Noyes has made possible and which will provide a fitting and beautiful memorial to his wife, will be completed in January, 1916. Already the workmen have begun the construction of the building, which will cost over $450,000.

The site—that between the School of Eduation group and the women's dormitories—is strikingly suggestive, not only of the thought which the University gives to its women students, but of the extent of ground over which its buildings are now being erected. This is the sixth structure facing the Midway Plaisance, the broad avenue of the South Park system on both sides of which for over half a mile the University owns the land.

The new women's building will be provided with every modern facility which such a hall should possess—reception and committee rooms, restaurant, gymnasium, and swimming pool; and in an adjacent space is the women's hockey field.

NOTES ON NOTEBOOKS.[1]

By John G. Coulter,
Bloomington, Ill.

By notebooks I mean those which high school students make in connection with their science courses. The history of such notebooks I do not know, but, whatever it is, I think a new chapter in it ought to be written.

It used to be the fashion, in writing or speaking about science teaching, to begin with the story of Agassiz and the dead fish. As I understood it when a boy, Agassiz put a fish down in front of a freshman. He told the freshman to look at the fish, to keep on looking at it for a week, and to write down in a notebook everything he saw. When he came for a new assignment, the freshman was told to continue with the fish. That is all there was to the story, but it was enough to make a strong impression upon a boy whose father, as the boy understood, had invented something called protoplasm. The fish story made him think that to be a scientist must be the dullest of occupations. For what could be more dull than the making of notebooks about dead fish? Dead things, through much experience with museum jars, had long since lost their power to please.

So now, in groping for the beginnings of notebooks in high schools, my mind goes back to that freshman. He contemplated his dead fish, and wondered what in the world to observe next. To relieve his perplexity, books were written. There was the handbook of plant dissection which told you a hundred things to observe about a liverwort. In it, and in similar guides for animals, the embarrassed freshman found relief. He became as busy and alert and a little more thoughtful than a census-taker. He sharpened his pencil to a delicate point, he scrutinized his material painstakingly, and then, "by notes and carefully labeled drawings," he recorded precisely what the helpful guide told him to record. He was being "trained in observation."

Having been well trained in observation, it did not take him long after graduation to observe that life, being empty of guides and full of buffets, is a very different thing from a laboratory. So he sought the laboratory again, and, being well-recommended, became teacher of science in a high school.

In those days students entering college were considered as

individual cases. Evidence of the work in science was needed. What better than the notebook, with its "carefully labeled drawings"? At least this was a product made familiar to the teacher in his college experience, and held in great, if somewhat fatuous, respect.

From such beginnings, I think, the notebook came to be the thing it is now, a thing which each year consumes teachers' hours by the hundred thousand, and pupils' hours by the million. Are we getting reasonable return on this huge investment?

* * *

Now to believe in the importance of a notebook is simply to believe in the importance of the organization and expression of thought, and the principal criticism of notebooks is that they provide for organization and expression but do not adequately provide for thought.

My own opinion is that some sort of notebook is an indispensable adjunct of a science course; a notebook which is critically examined by the teacher and made of record. But I think it should not be the sort of notebook I have seen in the majority of near three hundred high schools.

In criticising notebooks I do not charge a fault to teachers. I charge no fault at all, unless it be to "conditions." Now "conditions" in this democratic country generally go back to the state of the public mind. Manifestly we cannot expect the public mind to have a "state" on the subject of science notebooks in high schools. We can only ask the public to pay more for education; to pay more, so that, among other good things, science teachers may have the time and the training to make the notebooks, not better looking, but more profitable to those who make them. And because the public *is* acquiescent, generally speaking, in larger school bills I believe that a new chapter in notebooks may be written. This is one of the important items in the improvement of what we already have. The pity is that new money generally goes for new things, things which make fine show, rather than for improvement of what we already have. *High school science departments need more teachers and fewer teaching hours far more than they need more apparatus or more of anything else of which I can think.*

* * *

In theory there is much to say in favor of notebooks which express individual reactions to the material presented; neat and

careful they should be, but personal and expressive of real thought they must be. In theory there is much to say against rigid conformity to a set pattern, against any plan which insures order at all costs, and minimizes the work of the teacher. There is to say, for example, that such a plan deadens the work and represses expression of individuality. So much for theory. Practice, alas, is and must needs be quite another thing.

This so desirable "expression of individuality," for example, is a terrible thing to manage in the making of notebooks. It is at odds with all set plans, it plays havoc with a teacher's time, it is the despair of all precisians who would reduce the teaching process to a system.

Inevitably the efficient teacher tends to be a precisian. Yet in relaxed moments he recalls that the very heart of his task is the cultivation of this so-troublesome "expression of individuality." He recalls that methods which lead to however beautiful show-pieces are curbs to such expression, and he smiles at the feebleness of his own best plans. They are feeble because individuality will not run like fluid into his or any other mold. It eludes us now and it will elude our successors. It changes with the generations and is amorphic like an amoeba.

So the schoolmaster, whose business is with individualities in their amoeboid period, sets up his ideal. He devotes his life to compromise therewith, and in occasional approximation thereto he finds his scant reward.

This ideal is the thing we think we might accomplish if we gave all our time to just one instead of to many. It is the thing which goes out of the door when the second student opens it. Circumstances compel its exit.

Thus as to the science notebooks. Theory tells us to get into them all the originality we can extract from our pupils; it tells us that the notebook *should be* the best extractive tool in our kit. But experience urges another thing. It urges uniformity on us and we urge it on our pupils. It bids us keep in close step our five classes and their more than a hundred members. Else we shall soon be hopelessly swamped in the correcting of papers.

Common practice reveals an assumption that a set-pattern notebook, duly checked and approved, is a better thing than one abundant in originality, but hastily-scanned and loosely-checked. Certainly it is a better thing to show—a prettier thing at any exhibition. And *just* the thing if all our notebook makers are to become account-book keepers. Bookkeeping is a pretty and a

useful art, but somehow it has a sort of synonymity with non-originality, and no one has yet named it as one of the chief aims of high school training.

A laboratory manual which thousands use contains this typical sentence in its introductory matter:

"If the number of parts labeled in the drawing is unequal, then the last or odd label should be placed in the space at the bottom of the dividing line, thus insuring a neat and symmetrical page."

One emerges from such a sentence with a sense of suffocation. It makes you wish to strike out for air, or to get where you can see at least more than two inches from your nose. If "administrative conditions" compel in our high schools such cut-and-driedness as this indicates, then science is failing and its "problems" are pretense.

* * *

So in this matter of the expression of individuality in notebooks, we compromise. We balance the claims of the pupil with the rights of the teacher and declare that *as much rein and no more should be given to individuality as is consistent with definite results and with the teacher's working hours.* It follows that the smaller and fewer the classes the better the notebook should be.

This extent to which individuality is to be encouraged determines, of course, the nature of the directions given to pupils, and they, in turn, determine the amount of time needed by the teacher for going over the books. Teaching under conditions ideal as to size and number of classes, I have found three minutes per student-exercise to be the *average* of time expended in going over notebooks. The variations in particular cases were, of course, enormous, ranging from a few seconds to more than ten minutes—this, in addition to ten minutes per student per fortnight given to individual conferences, and these conferences I have found to be of indispensable value.

Some teachers have five science classes of near forty each. Others teach a number of subjects other than science. Under such conditions there is much excuse for completeness and explicitness of directions, with consequent restraint of individuality and dearth of thought. The laboratory exercise, with all its tradition of initiative and first-hand interpretation, becomes a series of observations and confirmations. It may rouse (or fail to repress) thought in a few, but much thought turned loose in such a laboratory would be like a bull in a crockery shop, upsetting all plans for getting over certain ground before the bell rings.

There must be a curb on thought, and a prod for the lockstep, and presently the class may emerge together at the place assigned. There can be quiz-conferences, of course. In these, set plans can be avoided, and there may be some pulling up of weeds in the half-suffocated crop of ideas, but the teaching conditions are all against thorough cultivation. In the end the teacher may take comfort in the drill given in certain useful information and in the organization thereof, but he can take little comfort if any in what has been taught of science as method or in what has been contributed of power to think. And because these last mentioned items are the best of all of science-in-education we should all be actively hostile to allotments to one teacher of five classes of thirty-to-forty. To make such allotments means waste of money, which is bad, and means waste of pupils' time, which is worse.

But give us, on the other hand, not more than four classes of not more than twenty-four in each, and let us see what is reasonable to expect. Give them to us in their seventh, or their eighth, or their ninth year in school, whenever it is that they are to begin science, let us have them for two years to carry through a general elementary course, and we can arrive somewhere, both in organized information and in thought arising therefrom. And the most vital part of such a course would take form in the notebooks.

There will be class notes, and field notes, and laboratory notes, and individual reports, and notes on reading, and perhaps other things. All these will be dated carefully, captioned properly, and filed in right order. Beyond that, the less of set plans the better.

The notebook should be filed in the laboratory, ready, not so much for perfunctory going over as for reference concerning any particular case up for consideration at the moment. To the teacher they will be indispensable guides, guides as to how best to help a sluggard boy or show an impulsive girl the value of deliberation. Of course they cannot be such guides unless, somehow, the boy and the girl have put a little of their real selves in between the pasteboard covers. But copious directions fairly slam those covers in the face of thought and originality, and the manual which "goes with the book" is like the commercial guide who goes with scenery and cathedrals, cramming them down your throat. Travel guides and laboratory guides are alike in interference with deliberate thought and appreciation. You wonder whether your youngsters are capable of deliberate thought?

Have you yourself ever given deliberate thought as to which and how many of your laboratory exercises are favorable to this desirable process? Haste and competition are among the things not favorable to it, yet haste and competition appeal to youth, and the teacher whose pupils wave their hands and make hasty replies finds it hard to remember that such pleasant liveliness needs restraint.

Notebooks and test papers we can make the living documents of our profession, or we can make them so much good paper wasted with black marks, mute, stone-mute, of what really happened in the heads of those who wrote them. Such are records of mental side-shows. It is the big show we want on record, sprawling and awkward, blotted and ungrammatical though this record may be at first. And we want all the papers from the first, poor sheets and good sheets together, kept somewhere. They are not to be graded and thrown away, the only record of them a numeral in a book, and they are not to be "done over." They are, for the student who made them and for his teacher, a record of development.

Correcting notebooks a bore? Of course it is if it be no more than the checking of conformities or non-conformities to a specific plan. But if it be a looking to see how many fish you have caught in the net for ideas you have cast, what then? I have been delighted to find it no more at all, but just as interesting as it used to be to follow the box-scores of a favorite ball team.

Is it not true that the most important contributions to the science of education have been based on careful study of pupils' written work? Is it not true that materials for such study and for such contributions are at every teacher's hand, materials for careful study and judgment of stimuli and reactions? We may search the notebooks for unexpected as well as for expected things, for evidences of the merits and the demerits of our method, for evidences of what our pupils really are, and we shall find them there unless it is we ourselves who have kept them out. We may scrutinize the pages as carefully as the old placer miner used to scrutinize his pan, and in like temper, for gold we shall find there, the gold of ideas, gold for us to refine and for them to cash in.

How, you may ask, is one to make such diligent study of notebooks in addition to the time spent in correcting them? My own opinion is that much of the time spent in correcting them is time which may be saved, and saved to good advantage. I do not

believe in having work done over, at least not after the first few exercises. The teacher must be sure that the directions given, both as to notes and drawings, are fully understood. He must be on his feet among the class making suggestions and corrections as the work progresses. Even then a good many of the early papers will have to be done over before the standards of orderliness in form and expression are appreciated. But after the work is fairly under way, there should be no doing over. The student should expect to be graded on the work as it is first turned in. It is not fair to him to know that he will have an opportunity to do the work over, nor is it fair to the teacher to have his time taken up by the neglectful.

If high schools fail in one thing today it is in imbuing respect for diligence and concentration of effort. The student who is diligent and concentrates his efforts turns in clear cut work the first time. The schools are criticised because they turn out students poor in arithmetic. This is not to be amended merely by changing courses of study or by making the problems more interesting. It is to be amended by teaching how to handle problems in general, how to focus on the one in particular which is before us and bring to bear on it all the benefit of an orderly training. For such training the laboratory and the making of the notebook have obvious advantages.

* * *

To make notebooks of the nature indicated, the first thing to get into them is sincerity of effort. Perfunctoriness, almost a virtue under Professor Cut and Dry, we must make our students hate. Hate, I think, is the word. Mere avoidance is not enough. Procrastination, carelessness, mental laziness, these are to be hated, hated for their stupidity, abhorred for their circumventions of bright dreams, fought like enemies. And the notebook is a real battle field on which to meet them.

It is not difficult to get boys to put sincerity of effort into every stroke of a tennis racket or swing of a ball bat. They are quick to see the folly of doing anything listlessly, that is, anything which has to do with athletics. Somehow, with each new class, discounting former disappointments, I find myself optimistic about getting them to take their notebooks in the same vein that they take their sports. Of course it is absurd to expect that, as a class, they will do so. They are boys and most of them not yet sixteen. Still, that seems the way in which to go at it.

What about the girls? As a class, they do show some pleasure

in the cut-and-dried kind of notebook. But let us remember that they also have an instinctive liking for sewing and embroidery, of which formal notebooks often forcibly remind us.

* * *

In this whole matter of high school science I have observed two kinds of counsellors. There are those so imbued with ideals that they are unwilling to accept any compromise. Generally speaking these are university men. I recall saying to one of them that I thought most teachers attempting to follow his advice would flounder. Said he, "then let them flounder; it's good for them." I could not follow him quite so far and am sure that "practical school men" are deaf to such counsels.

The other kind is practical. In fact more practical than scientific. They would not let teachers flounder, and they would make of science courses a thing which is science in name only. But that thing is easy to teach, all its steps are definitely formulated, and it appeals strongly to that kind of practical school man whose practicalness consists chiefly in rigidity of method. Counsellors of this kind are good friends of medocre teaching. They have written the books of largest sale. Leave it to them, and the whole problem of science teaching is already solved.

Now in this matter of notebooks I hope it is possible to formulate specific advice which is somewhere between the two extremes thus indicated. I hope that there are plans both conformable to our ideals and attainable by ordinary teachers, not dependent upon extraordinary talent and personality. It is of what I conceive to be such plans that I shall write.

USES OF TUNGSTEN.

Tungsten is used principally as an alloy of high-speed steel—that is, steel used in making tools used in metal-turning lathes running at high speed—to which it imparts the property of holding temper at higher temperature than carbon steels will, according to the United States Geological Survey. The now well-known ductile tungsten is used for incandescent lamps, which are fast displacing carbon lamps. Recently greatly improved lamps, in which the wire is wound in helices and in which the globes are filled with nitrogen, have produced a close approach to white light. These lamps are furnished in candle powers up to 2,000. Ductile tungsten is practically insoluble in all the common acids; its melting point is higher than that of any other metal, its tensile strength exceeds that of iron and nickel, it is paramagnetic, it can be drawn to smaller sizes than any other metal (0.0002 inch in diameter), and its specific gravity is 70 per cent higher than that of lead.

THE PRESENT STATUS AND REAL MEANING OF GENERAL SCIENCE.

By Fred D. Barber,
Illinois State Normal University.

(Continued from March Issue.)

General science as conceived by its leading advocates is quite as much a different mode of organization and a different mode of attack as it is a new and different selection of material. Much of the material which has thus far appeared in texts called general science consists of clippings from the special sciences. To a less extent the same is true of the outlines received. In many cases little or no unifying idea giving the unit of instruction significance is evident. In my judgment, the advocates of special science, with justified reverence for logical and scientific thinking, may well call such a course "hodgepodge" and dub it a "spineless wonder."

If general science is to be of educational value, it must consist of well organized units of instruction. These units must be as definite and as well organized as are the units of special science. They will differ, however, from the units of special science in the fact that they are units of practical science or applied science instead of units of theoretical science. The core of the unit in general science will be some process or some device utilized by the individual or by society in the ordinary activities of modern life. To illustrate: In the special science, physics, under "Light" we find such units as these: Light, Its Rectilinear Propagation; Shadows; Photometry and the Law of Reflection; Mirrors and the Formation of Images; Refraction of Light; The Formation of Images by Lenses; Optical Instruments; Color and Spectra; Nature of Light; Interference and Polarization.[1] In marked contrast, general science, adapted to the ninth grade, will be developed through units of instruction somewhat of the following character: Primitive Lamps; Candles; How the Candle Burns; Discovery of Petroleum; Kerosene Lamps; How Kerosene Burns; Evaporation, Boiling-point and Distillation; Crude Petroleum; Distillation of Petroleum; Gasoline; Why Gasoline is Dangerous; Inspection of Oils; Cautions in Using Kerosene and Gasoline; Gasoline Lamps; Gasoline Gas; Illuminating Gas; Distillation of Coal; Coal Gas; Water Gas; Acetylene Generators; Acetylene Lighting; Electric Lights and Electric Lighting; Natural Lighting of Rooms; Direct and Diffused Light; Importance of Diffused Light; Intensity of Light Required; Cost of Artificial Lighting.

A course in general science properly conceived, has unity and logical development. It has educational value of the highest order. It is adapted to the adolescent mind and at the same time appeals to the pupil as worth while. It trains in scientific thinking and deals with material with which the pupil is already somewhat familiar. It starts with the known and proceeds to the related unknown. It deals only with the concrete because the *significant is always concrete.* It gives the pupil control of his environment and an appreciation of the significance of science in modern life. Such a course in science study is *general* because it disregards the artificial boundaries of special science. To study tallow or paraffin candles, how they are made, how they burn, and their significance in the development of civilization involves material from several different special sciences. The units of applied science are never drawn from the field of a single special science. The science of raising corn on the fertile plains of Illinois involves some knowledge of the history and character of the soil itself, *geology,* some knowledge of the structure and composition of the soil, *soil physics and soil chemistry,* some knowledge of the plant life and plant growth, *botany,* some knowledge of the weather and climate, *meteorology,* and some knowledge of insect life, *zoölogy.* Why do we insist that the pupil be eternally separating these elements of nature—these items of his natural environment which the Creator has so marvelously and wondrously fitted together into a perfect whole? Why do we insist that he forever and eternally be separating them from their natural, logical, and necessary relationships and placing them in the man-made category of special science? Is there less education, less mental training, or less culture in seeing and comprehending the units of nature as designed by the Creator than by seeing and comprehending the units designed by man?

The Plea for Special Science.

Occasionally we hear an advocate of special science in the high school presenting his case. While admitting that science instruction in the high school may, at this time, very justly have been called to the bar of public opinion, he still insists that science instruction is improving daily, that the rank and file of science teachers will soon be so prepared that they can present special science in an interesting and profitable manner. He closes his argument with the statement that to substitute general science for special science in the early years of the high school

at this time would completely upset the entire course in science, set science in the high school back a generation, and inevitably mean a great and deplorable loss for the cause of education.

I never hear such an argument without recalling another case which is recorded in that delightful volume, "The Biography of Thomas Wentworth Higginson," by Mary Thacher Higginson. Not long after the close of the civil war a very attractive young woman appealed to Mr. Higginson to attempt to secure a pension for her on the grounds that she was the daughter of a certain man, that he was a Union soldier, and that he died of starvation and exposure in a Confederate prison. Mr. Higginson, after a careful and thorough investigation, summed up the case. He announced that he found the case a difficult one to handle. The beauty, brilliancy and culture of the girl were all in her favor, but there were three strong points against her case which would be difficult to overcome. First, she was not the daughter of the man as represented. Second, the man never was a Union soldier, and never was in a Confederate prison. Third, the man was still living, well and hearty. He concluded to drop the case.

Now, as I understand it the theory is that special science is the only science instruction having any considerable cultural and educational value—that it is only when the great truths of nature are thus presented that one can see the natural and physical world as a unit and in its logical order, and, finally, that it is only when one thus studies nature that one acquires the scientific spirit. This theory while beautiful, brilliant and attractive must be considered in the light of some cold, hard facts when applied to adolescent minds in the early years of the high school.

First, the adolescent mind demands no such view of nature as will enable it to see the unity of the universe nor even such unity as is presented in a special science. The child mind is not the mind of the philosopher. The adolescent mind demands merely an explanation—a simple common-sense explanation—of his environment, a working explanation of the here and now.

Second, special science, as usually developed, deals with abstractions and generalizations. These are usually arrived at through type-studies. The best and most striking types are often found outside of—rarely within—the range of the pupil's past experience. The material placed before the student may have the semblance of concreteness but in reality it lacks concreteness because material is concrete only when it has significance and meaning in the light of past experience. No matter how concrete

in form material may appear to the teacher with his more mature mind and richer experiences, if it lacks significance in the pupil's past experiences it is to him abstract and consequently lacks interest.

Third, special science has had its trial in the early years of the high school and has largely failed. It has failed to interest the pupil; science teachers generally regard it as more or less of a failure; superintendents, school boards and especially thinking patrons and hard headed business men have lost faith in it and are demanding a change in science teaching as well as in other phases of high school work. While the significance and importance of applied science in modern life have multiplied many fold, science instruction has steadily declined during the past 20 years. If the rate of decline continues at the past rate for another 20 years, science will then occupy but an insignificant place in the high school curriculum.

We can not much longer disregard these potent facts and cling to the theories of specialists and research enthusiasts when shaping up science courses for fourteen-year old boys and girls just entering the high school.

General Science Is Concrete.

Science may be organized into units having practical application and more or less utilitarian values for a basis with exactly the same logical sequence as when organized in accordance with purely theoretical considerations. The science involved in the production and use of light from the pine knot and grease lamp of primitive times to most modern methods of lighting may be as well organized and will require the same logical thinking and be of as great educational value as is the organization of the material usually presented under the head of light in a special science, physics.

When science is organized upon the basis of practical application and utilitarian values only significant material is required. Our textbooks in special science today are in a great measure loaded down with non-significant and therefore abstract and uninteresting material introduced solely because of theoretical considerations. As a teacher of physics principally engaged in teaching students of secondary school attainments I assert with confidence that at least one-third of the subject matter in the ordinary physics text may be omitted without practical loss to the ordinary high school student and with a positive gain in interest.

Organization of General Science.

I repeat, the significant material of science may be organized into units of instruction presenting as much of logical order and sequence as is to be found in special science. Consider physics for a moment: There is no accepted order of topics in physics. Some texts begin with the mechanics of solids, some with a study of liquids. In some texts sound is presented early in the course; in others it comes late. In every physics text there are complete breaks in the logical sequence, as for instance in passing from heat or sound to static electricity. Several popular texts have even divided the usually accepted units, presenting a portion of the topic early and the more difficult portions later in the course.

An examination of the texts in physics published during the past 25 years will convince any fair minded person that there is no accepted logical sequence of topics in the subject of physics. The same lack of accepted sequence is even more strikingly evident in chemistry. About thirty years ago the order of topics in zoölogy suffered a complete reversal. Previously the higher forms of life had usually been treated first and the lower forms last. Man was the first topic studied and the amœba the last. An examination of all the texts of special science during the past half century would prove conclusively, I believe, that authors never have recognized, and do not today recognize as necessary a certain sequence of topics. Of course, within a unit of instruction a logical sequence is observed but history proves that special science demands neither that a certain fixed and unvarying set of topics be treated nor that those which are treated shall be studied in a fixed and unvarying order.

Now, the general science advocated today violates no accepted principle of science teaching in proclaiming that there is no single set of topics which should be treated in every school and every class and further that there is no set and invariable order in which the topics chosen may be treated. In these respects special science has never been universalized and it is to be hoped that general science may never be universalized. Nevertheless, science to be significant and concrete must reveal to the pupil his environment. Now, there are certain phases of environment which are universal or nearly so. These phases of environment may be organized and developed into a course in science. If organized in accordance with the basic principle of revealing their utilitarian, social, and economic values, I believe we shall have organized a course in what progressive educators now call general

science. Such an organized course will differ materially from our usual courses in special science both as regards the materials used and the mode of presentation.

A Course in General Science.

It is my conviction that the first year, probably the first two years, of science in the high school should be organized as general science as interpreted above. Some of the larger units which have universal significance to high school students may be mentioned. The list is far from complete and will need to be supplemented or trimmed down to meet the conditions in special cases. But such an organization will furnish the basis for an acceptable course covering one year's work in almost any high school.

1. The production of artificial light and the use of natural and artificial light in the home and school.
2. The production and uses of heat in the home, in the school and in the manufacturing industries.
3. Refrigeration and its uses in modern life.
4. The weather.
5. Climate and its relation to health and the industries.
6. Ventilation—its principles and how obtained.
7. Micro-organisms—their relation to health, soil fertility, and the industries.
8. Food, and the nutrition of man and animals.
9. Soil physics; water supply and sewage disposal.
10. Machinery in the home and on the farm.

Our plea is not for an easy, a snap course, nor for a sentimental namby-pamby course, but rather for a course full of meaning and value, and one which will enlist the interest and best effort of the pupils. It must rest upon an historical setting and reveal to the pupil so far as possible the social and economic value of science in modern life. It must recognize the nature of the adolescent mind and must appeal to the pupil and his parents as worth while.

ADAPTING INSTRUCTION IN ALTERNATING CURRENTS TO HIGH SCHOOL CLASSES.

BY ELMER E. BURNS,
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There are two places in the high school curriculum for the teaching of alternating currents. First, in the course in Physics. If there is any subject that is both fundamental and practical in connection with the study of electricity, alternating currents is such a subject. Since the current in the secondary winding of every induction coil, the current which reproduces the sound in every telephone receiver, and the current in the armature of every dynamo is alternating, and every long distance transmission line carries alternating current, how can the physics teacher avoid teaching some of the principles of alternating currents? If the school has a third semester of physics, and the class happens to be a class of boys interested in electricity, there is nothing better than a thorough study of alternating currents, nothing that will help the boys more in practical electrical work, nothing of greater interest from the point of view of electrical theory.

A count of the articles listed in the Engineering Index indicates in a striking maner the relative importance of alternating and direct current in engineering. Articles on alternating current topics outnumber those on direct current topics about four to one.

The second place for the teaching of alternating currents is in vocational classes in electricity. I will digress here for just a moment on the subject of vocational training. Such training should be something more than the training formerly given to apprentices and now taken over by the schools. There is a tendency to swing to the extreme of merely preparing for trades. While vocational education is in its infancy there should be determined opposition to the tendency to make a man merely a tradesman instead of a highly developed human being. The ideal condition is that every man should be an inventor, or a discoverer, applying his creative power to his own calling instead of being a mere accessory to a machine. The schools must put a bigger meaning into vocational training than has yet been put into it. To make the application to electrical teaching, the electrical worker should be taught, first of all, fundamental principles making manipulation secondary or, to express the same thought in different form, using manipulation as a means of fixing in the

mind the fundamental principles and acquiring a broad knowledge of the subject of electricity and a view of its relation to the life of humanity.

I have taken pains to interview a number of employers in the electrical field and they agree in saying that the men who wire our buildings do not know the first principles of electricity. The man at the head of the meter department of the General Electric Company said to me that the greater part of the electric wiring in Chicago is guess work. The majority of the wiremen are mere tradesmen and incompetent tradesmen at that. What these employers want the schools to do is to teach fundamental principles —not shop kinks. One of them said that he would rather take a boy who had a thorough knowledge of Ohm's law and knew nothing about wiring than a boy who was an expert wireman and did not know Ohm's law. The former he said could readily learn the shop kinks in actual work, but the boy who did not get the fundamental principles in the schools was not likely ever to get them. He would be stumped by every new problem he met.

Direct currents should, no doubt, be placed first in any scheme of instruction in electricity but alternating currents are too important to be omitted. We have been trained to think of alternating current phenomena in terms of the calculus or as requiring at least a knowledge of polar coördinates and therefore as being a fit subject for study only in the university or engineering school. Is it possible to simplify instruction in alternating currents so as to bring the fundamental principles of the subject within the grasp of high school pupils? My experience is that it is possible to teach boys in the high school the principles of alternating currents including self-induction, power factor, phase relations in polyphase circuits, etc., so that they will have an intelligent understanding of the subject. Since this is possible why should not the men who wear overalls and do our electric wiring, and tend our switchboards and dynamos know the principles of electricity, including alternating currents?

Alternating currents, as I have said, have been regarded as too abstruse for elementary instruction. Hence the subject is taught in the electrical engineering courses while the great army of electrical workers, who never see the inside of an engineering school, work on in ignorance, or with false conceptions of the mode of action of that entity on which their work depends. This unfortunate view of instruction in the most important branch of electricity has prevailed because we have been following Max-

well in our methods of interpreting alternating currents. We have lost sight of the simpler method of Faraday. Steinmetz is the criterion in electrical instruction today but how many electrical engineers ever make use of Steinmetz's "Alternating Current Phenomena?" Most engineers are too busy for that. They use tables and formulae—many of them empirical. What then of the dynamo and switchboard tenders and electric wiremen, of whom there are dozens for every electrical engineer, and what of the boys who are to fill these positions? Cannot they have an intelligent understanding of what goes on in an electric circuit so far as is possible in the present state of knowledge? If this knowledge can be imparted to these workers then the electrical work of the world will be intelligently done.

Instead of interpreting the electric current in mathematical formulae as Maxwell did we must interpret it in images as Faraday did—visualize the magnetic field and lines of force. In alternating currents we have a constantly changing magnetic field, a magnetic field in action. Give the pupil a picture of this magnetic field in terms of lines of force. The Maxwell method has its uses for the designer of dynamos and other electrical machinery but not for the high school pupil nor for the average electrical worker.

It is possible to impart an adequate knowledge of the fundamental principles of alternating currents by the Faraday method. By this I mean to construct an adequate picture in the mind of what goes on in an a. c. circuit. Then the electrical worker can work intelligently and if later he takes up the mathematical phase of the subject he has a better foundation on which to build than if he had begun with mathematical formulae. Faraday did not think in mathematical formulae but in images and in that respect most students resemble Faraday rather than Maxwell.

The principles of alternating currents can be taught with simple apparatus which is within the reach of every high school and the only electric circuit required is the ordinary 110 volt a. c. lighting circuit. With such an equipment the principles of polyphase as well as of singlephase currents can be demonstrated.

We begin our study of alternating currents with the standard experiment on the magnetic field mapping out the field with iron filings and with small compasses. It is important that the pupil should form a correct mental picture of the magnetic field and lines of force for on the action of the magnetic field depend the principles of mutual and self-induction, the generator, the trans-

former, and every type of electric motor. The pupil can readily grasp the idea of lines of force as representing both direction and magnitude of the force.

We next take the simplest experiment on induced currents. Connect a coil to a mill-voltmeter having a zero-center scale. Thrust a bar magnet into the coil. The pointer moves showing that a current is flowing in the coil. Withdraw the magnet and the pointer moves in the opposite direction showing that a current is induced which flows in a direction opposite to the first. Repeatedly insert and withdraw the magnet and you have an alternating current in the coil. It is the lines of force of the magnet moving across the coil that induce the current. The current is reversed every time the lines of force change direction across the wire. Thrust the magnet more quickly into the coil and the pointer moves farther than at first showing that the strength of the induced current depends on the rate at which the wire cuts the lines of force.

Following these simple, fundamental experiments we proceed with the aid of experiments and diagrams, some of the experiments being performed by the pupil himself, to the principles of mutual induction and the transformer, the repulsion effect and Lenz's law, self-induction and the choking coil, the solenoid and plunger, magnetic permeability, effect of capacity and the fact that capacity can be made to neutralize the effect of self-induction, the first principles of polyphase circuits, and the rotating magnetic field and the induction motor. It is not difficult to present these principles so that a class of high school boys will understand them as they proceed and be constantly eager for more.

GASOLINE FROM NATURAL GAS.

The extraction of gasoline from casing-head gas (natural gas from oil wells) has become one of the important adjuncts of the natural-gas industry in the United States. The production is increasing rapidly, the quantity produced in 1913 having almost doubled that of 1912, owing to the installation of a greater number of plants and to the advance in the price of gasoline.

The uses of natural-gas gasoline are many and varied. It is principally used for raising the standard of naphthas or low-grade distillates consumed in motors; it is also used for lighting; and it can be used like regular gasoline in all the arts. There is an ever-increasing demand for this gas to be used in automobiles.

INTERESTING TECHNICAL POINTS ON GEMS.

By Frank B. Wade,
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(Continued from March Issue.)

This complete separation of the different colors of light constitutes the cause of "fire" in the diamond.

The separation of white light by differing refraction in the above manner is called "dispersion." The degree of dispersion differs in different gems. The diamond and the few other gems listed in the first part of this article as showing "fire" do so because of the high degree of dispersion which they possess.

A quantitative measure of this dispersive power is of great use in accurate determinations in physics, and the measure adopted is called the coefficient of dispersion. It is a number obtained by subtracting the index of refraction of light of a certain wave length in the red from the index of refraction of light of a certain other wave length in the violet end. In other words, the coefficient of dispersion of any gem is an accurate measure of the degree of separation that gem is capable of producing in light of the various colors.

The greater the dispersion the more "fire" a stone can have if it is colorless.

If colored the material absorbs and fails to pass light of colors other than its own, and thus cannot display any marked "fire." Absorption similarly takes place in off-colored diamonds, but to a less degree owing to the thinness of color. It is largely because of this absorption and the consequent weakening of the "fire" that off-colored diamonds are less valued than white ones.

The separation of white light into prismatic colors by the opal depends on an entirely different principle, and is due to the effect of very thin films of material filling minute fissures in the opal. Here the effect is similar to the color effect seen in soap bubble films.

If the device of employing a white card to catch the light thrown by a brilliant held in the sunlight is employed, the spectra thrown by the stone can be easily studied.

If a white sapphire be used instead of a diamond it will be found that it, too, disperses light but that the spectra are very much narrower than in the case of a diamond (red and violet much nearer together); that is, its coefficient of dispersion is much less. Moreover, being doubly refractive (see previous article),

two spectra result from each facet, and hence the light is diluted or thinned in intensity. For these two reasons—the lack of large dispersion and the doubleness of the refraction—the white sapphire and also the white topaz, colorless quartz and other colorless stones, do not have appreciable "fires." The short spectrum given by the white sapphire crosses the eye so rapidly when the stone is moved that the colors blend in a white flash, the eye being unable to distinguish them separately.

The colorless zircon, however, has a coefficient of dispersion about 86 per cent. as great as that of diamond, and in spite of its double refraction is capable of displaying considerable "fire" when well cut.

QUESTION 2. *"Define Dichroism."*

ANSWER.—In connection with the answer to this question we shall describe an instrument, the dichroscope, which is of considerable practical importance to the man who has to determine the identity of colored stones.

It is among the colored stones especially that there is most confusion and error on the part of the retail dealer, who relies chiefly on color for a means of identifying such stones, and there is no more unreliable property. Such a wide range of color exists in the same "mineral species," the tourmaline, for example, which may be colorless, pink, brown, green of many shades, yellow, red, blue or black, that to rely on color alone in a determination is to expose one's self to a great likelihood of error. Some red spinels look so much like some true rubies, for example, that the color alone is scarcely sufficient to distinguish them. I have seen such red spinels offered for sale as true corundum rubies by honest retailers who were merely mistaken in their identification. I have also found true corundum rubies offered for sale as spinels, although they would have brought more under their true name. It is thus evident that the use of an inexpensive instrument like the dichroscope is called for on the part of anyone who has any considerable need for identifying precious stones. Even the retailer who handles relatively few such stones could well afford the possession of such an instrument, as its cost (some $6 or $8, according to make) would be more than made up by a single discovery of wrong species in many cases. The only other instrument that affords anything like as sure a means of identifying colored stones without any possibility of doing them an injury, is the refractometer, which determines the refractive index of the material, and refractometers are far more costly than the di-

chroscope and, with the exception of the Herbert-Smith refractometer, which has a scale on which the refractive index may be read directly, they are more difficult to use than the dichroscope.

Now for a definition of dichroism and a description of the dichroscope.

In a previous article where double refraction was discussed it was said that a beam of light on entering many kinds of crystallized material became divided, part following one course and the rest a different course within the material. Now some colored substances absorb these two resulting beams of light differently, so that on emerging from the substance one of the beams of light has a different color from that of the other.

Such substances are said to exhibit dichroism (literally, "two colored"). The tourmaline is especially strong in its dichroism, some brown specimens even absorbing all of one beam of light and emitting only the other when the light passes through the crystal at right angles to its principal optical direction.

The direction in which light falls upon a crystal makes a difference in the kind of absorption which results, so that in one type of crystal (that which is called optically uniaxial; that is, having just one principal optical direction) light that travels parallel to this principal direction is not doubly refracted, and, of course, no dichroism results. In any other direction in such a crystal (or in a gem cut from such a crystal), however, double refraction results, and in many species this carries with it dichroism; that is, differential absorption of color.

The other type of crystal (a biaxial crystal) has two directions in which single refraction results (and hence dichroism is absent). In all other directions more or less double refraction results, and in many colored stones this carries dichroism with it. Colorless stones, of course, cannot exhibit dichroism, and the more deeply colored a stone is, up to a certain point, the more strongly marked will be its dichroism.

The dichroism of the tourmaline and that of the ruby and sapphire can be distinguished by the naked eye by turning the stone or the rough crystal to different positions, when glimpses of the differing shades of color will be detected. It is, in fact, the dichroism of the ruby which gives to it a part of its superior charm over the spinel of red color. The latter is singly refracting in every direction and hence can display no dichroism. Its color is,

therefore, more monotonous than that of the true ruby, which is ever changing in hue with change of position.

Many colored stones, however, possess dichroism to too slight a degree to be easily noted with the unaided eye, and to determine these, as well as to be sure of even the more strongly dichroic substances, the dichroscope has been devised.

This little instrument is very simple in its construction, and is easily used after a little practise.

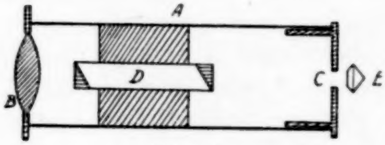

FIG. 3.

It consists merely of a brass tube, A Fig. 3, blackened inside and provided with a simple lens, B, at one end and a cap with one small square hole, C, at the other end, while inside it is placed a crystal, or rather a cleavage rhombohedron from a crystal of Iceland spar, D. The latter is usually provided with two glass prisms, cemented on its two ends to square it up so that one may look directly through it rather than at an angle. The lens is of such focus that a stone held in front of the square hole and close to it is seen clearly.

On looking through the instrument at some bright object or at the sky, two images of the one square hole are seen, as Iceland spar is strongly doubly refracting, as was said in a previous article. If now a colored stone which was cut from a doubly refracting mineral that is dichronic—say a ruby—is held in forceps close to the square hole (in about the position of E, Fig. 3) so that light from beyond may pass through both stone and instrument, the two squares will be seen to be of different shades of red (usually carmine and aurora in the case of a fine specimen of ruby). If a ruby-colored spinel be substituted for the ruby the squares will both be of the same red. Likewise a garnet (which, like the spinel, crystallizes in the cubic system and is singly refracting) will show both squares of the same shade of red. A glass imitation also invariably shows the same color in the two squares. So would an ordinary doublet, as it is part glass and part garnet, neither of which are doubly refractive.

The shades that different dichroic gems give vary with the depth of color of the particular specimen and with the position in which

it is held. (As was said above, even doubly refracting minerals have one, or, in some cases, two directions in which they do not show any dichroism, and thus, to be sure that a stone is really singly refracting, it must be held in different positions before the instrument.) Some practise is, therefore, necessary before one can be sure of himself.

If difficulty is experienced in getting a strong beam of light through a well-cut stone a drop of oil of almost any kind, placed on the culet of the stone, will enable one to get light through it to the table.

In practise the instrument is perhaps of most use in distinguishing corundum rubies (true Oriental ruby) from red spinels, garnets, rubelite (red tourmaline), true hyacinth (red zircon) and other red stones and imitations, and in making sure that a stone is a real emerald, and not one of the strikingly similar-looking imitations, either in glass or in fused beryl which has been colored with chromium oxide. Neither the glass imitation nor the beryl glass shows dichroism, while the emerald (except when viewed up and down the axis of the original crystal) gives a bluish green and a yellowish green.

It should, perhaps, be said at this point that the artificial rubies and variously colored artificial sapphires on the market show dichroism like their natural relatives. Hence, the genuineness of a natural ruby or sapphire cannot be decided by the dichroscope alone. The well-known structural differences (curved striae and round bubbles) will, however, suffice to decide such cases.

There follows, in answer to the remainder of Question 2, a list of stones which "possess single refraction," and another list of those that "possess marked dichroism."

TABLE A.

Singly refracting gems.

1. DIAMOND.
2. GARNET.
3. SPINEL.
4. OPAL.

TABLE B.

Stones with marked dichroism

1. RUBY. } corundum.
2. SAPPHIRE }
3. TOURMALINE.
4. ALEXANDRITE (CHRYSOBERY
5. KUNZITE (SPODUMENE.)
6. EMERALD.
7. TOPAZ. (TRUE).
8. AMETHYST (QUARTZ).
9. PERIDOT (TRUE OLIVINE).
10. FALSE TOPAZ (QUARTZ).

QUESTION 3. *"Describe the various forms given to cut stones."*

ANSWER.—This question is one which every jeweler should be able to answer with ease, and it will therefore require but little discussion.

In order, however, to arrange and classify the different types of cutting in orderly fashion, a few paragraphs of description may not be out of place.

Perhaps the first form to be described should be the *cabochon cut.* The word comes from the Latin cabo (a head) through the French caboch (a baldpate). The appropriateness of the term is at once recognized, as the typical cabochon cut stone, when round in its outline, strongly resembles in shape a bald head. See Fig. 1, (*a*) and (*b*). The outline of the base in a cabochon may be circular, oval, pear-shaped or, in fact, of any symmetrical contour. The oval is perhaps most used. The height of the stone, as compared to the width and length, may be varied to suit the purpose for which it is intended or to save weight of the material if the latter is of some value.

In early times the cabochon was the only cut used, and it was then applied to both transparent and opaque materials, even to valuable gems such as rubies and sapphires. Its use permits the saving of more weight in the finished stone than the more modern cuts, as a rule, and even to-day, in the East, numbers of valuable rubies and sapphires are still worn and used in the cabochon cut. A few fine gems are cut and sold *en cabochon* in this country to people of quiet taste who prefer the rich coloring without the glitter of the brilliant or step cut stones; but for the most part the cabochon cut is used in modern jewelry for opaque or semi-opaque stones like the turquoise and the opal. Garnets are still frequently cut *en cabochon,* and when in that form the crimson garnet is now commonly known as the "carbuncle." Scientific rubies are also being cut in the cabochon form to some extent at present and make a very pretty stone, as their color is prettier than the dark yellowish or purplish red of the garnet and can be seen at a much greater distance.

When transparent stones are cabochon cut they should be given rather greater thickness than is usually the custom, in order to secure total reflection of as much light as possible from the flat polished base. The East Indian lapidaries apparently understand this, for high topped cabochons are found among their products. If the curve of one side meets that of the other at the top without much flattening the result is even better, as the

flat top surface of the ordinary low-cut cabochon is so nearly parallel to the bottom surface that, unless the stone is mounted over foil or over burnished metal, much of the light that falls upon it is lost through the back.

Fig. 4

Fig. 5

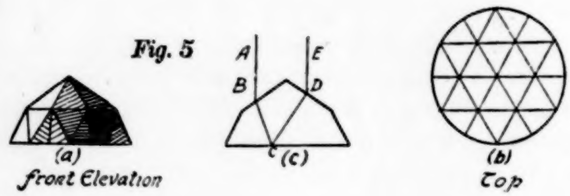

Fig. 6

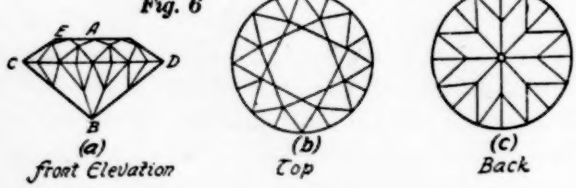

Fig. 7

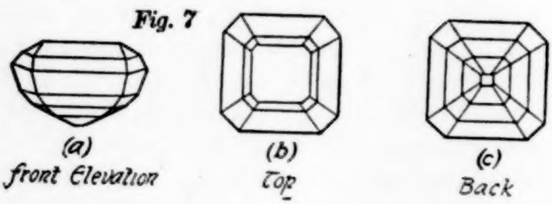

Fig. 4 (C) shows the contour of a cabochon which will light up better than the usual flat type. This will perform better with a circular outline than with an oval one, as the angles become more flattened in the long oval stones, unless a narrow ridge is kept on top, in which case the curvature at the ends may be made like that from sides to top and the result improved. As is the case with the rose cut diamond, the height of a cabochon stone should be about one half the spread to secure the best optical results with transparent stones.

The *rose cut,* which was just mentioned, is probably, after the cabochon, the oldest of the remaining general types of cutting. It was formerly applied especially to diamonds and is still used for small diamonds for encrusting, as the flat base lends itself to mounting on thin metal. A full cut rose has 24 triangular facets on its convex upper surface. Its base is flat and its outline usually round, although it might be oval or pear shaped, or of some other form. See Fig. 5 (*a*) and (*b*).

The path of a beam of light falling upon the top of a rose cut diamond is roughly indicated in Fig. 5 (*c*) by the lines A B—B C and C D and D E. It will be seen that the object sought is the return of the light to the front because of total reflection at C. If the rose is cut too flat the light is not refracted enough at B and falls so nearly perpendicularly on the base that it penetrates and is lost. In diamond, light must not come inside of about 24 degrees from a perpendicular path or it will penetrate and be lost.

The *brilliant cut* serves better than the rose to return light to the front of the stone, and practically all diamonds and many colored stones are now cut brilliant. As is well known to all, the brilliant cut stone has the shape of two truncated (cut off) cones placed base to base. The upper cone is truncated more than the lower, forming the *table* above (A) Fig. 6 (*a*), while the cutting off of the lower cone forms the culet B Fig. 6 (*a*). The edge of meeting of the two cones is called the girdle C D in Fig. 6 (*a*).

The upper cone is usually facetted with 32 facets besides the table, while the lower cone usually receives 24 facets besides the culet.

In small stones, or in those which must be cut more cheaply, fewer facets are used.

Fig. 6 (*b*) shows the usual arrangement of the top facets, and Fig. 6 (*c*) the arrangement of the bottom facets.

The proportions of the brilliant depend upon the refractive index of the material, and to give good results a stone must be cut within four or five degrees of the correct angles. Diamond calls for about the following proportions to give the best possible results: The top angle (ECD) Fig. 6 (*a*) should be about 35 degrees. The back angle (DCB) Fig. 6 (*a*) should be about 40 degrees. The thickness of the part of the stone above the girdle should then be left just about one-half as great as the thickness of the part below the girdle. This will give a table which will be about 4-10 as wide as the stone itself. The spread of the stone will be somewhat less than twice the thickness.

It is needless to say that not all diamonds are cut to this ideal shape; many would be more snappy if they were recut to correct form. Other considerations, however, justly come in, so that, to save weight or to save spread, many irregular rough stones are cut somewhat off from the best proportions. They are made to the "best salable" shape, as it is called. Too great a departure from the best shape should not be tolerated, however, as a diamond is nothing if not brilliant, and no great degree of brilliancy can be had in a stone that is much too flat or much too thick. It will pay many a retail jeweler to pay closer attention to the "make" of his diamonds. The public is becoming educated in these matters and the trade cannot lag behind.

In materials other than diamonds slightly different angles in the brilliant give better results. In general, as other materials have a lower refractive index than diamond, the brilliant should have a steeper back angle and a steeper and higher top to secure as much total reflection as possible. Zircon is about the only material that looks well when cut to the correct diamond shape, and even it does not light up equally all over the stone.

The materials such as white sapphire, true white topaz and quartz crystal, which have even lower refractive indices, cannot be cut to light up all over when seen from different angles. When cut as suggested above they will give full brilliancy when seen full face on, but they are weak and dark in the center when viewed from the side, and this lack cannot be remedied (except by the use of foil), as it is inherent in the optical properties of the material. Of course, such stones (except zircon) lack high dispersion and so give but little "fire."

The remaining general type of cutting is known as the *step cut* (sometimes called trap cut). It is largely used to enhance the color of colored stones such as the emerald, and perhaps lends itself better than any other cut to this purpose. It is today frequently employed for the back of stones which receive the brilliant cut on top, the resulting cut being called the "mixed cut."

As is shown in Fig 7 (*a*) (*b*) and (*c*), the facets on a step cut stone consist of two or more series of parallel edged facets above and below the girdle. There are usually two such tiers above and three or four below the girdle in the ordinary stone. The outline of the stone may be round or square or cushion shaped or triangular, or, in fact, of any regular shape. This style of cutting does not give as complete total reflection of light from the rear surfaces as does the brilliant cut. There being several different

angles employed in the back of a step cut stone, they cannot all be correct for the purpose, while in a brilliant, if the back angle is correct, it is correct all over. The advantage of the step cut is that, because of its rounding form, more of a mass of the colored material is preserved in the finished stone. This tends to increase the depth of color, as light must traverse more material before it emerges, and thus more complete absorption of light of colors, other than the fundamental color of the stone, results.

It should be borne in mind, however, that there is no color where there is no light, and such flat shapes as fail to return light to the eye in fair amount should be avoided even though weight and spread be very much diminished, as little beauty is to be seen in such flat stones unless they are held up to the light.

(To be Continued.)

MANUFACTURE OF OPTICAL GLASS IN AMERICA.

The glass used in this country for the manufacture of lenses is practically all imported except in the case of some of the smaller and cheaper lenses. For several years past, the Bureau of Standards, of the Department of Commerce, has been endeavoring to persuade the glass manufacturers of the United States to take up the manufacture of this material, but they have been unable to do so, partly because of the limited quantity used as compared with other glass, but largely on account of the varying composition required and the difficulty of annealing the glass, as good optical glass must be entirely free from strain.

With a view to working out some of the underlying problems sufficiently to enable manufacturers to start in this matter, the Bureau secured two years ago an expert interested in the composition and testing of optical systems, and a little later secured another man skilled in the working of glass to the definite forms required by the theory. These steps were taken first, partly because it is exceedingly difficult to find men having these qualifications, but principally because as the work of experimental glass making progresses, the glass must be put in the form of lenses and prisms to test; in other words, the Bureau had to be in a position to examine the product as it was made experimentally. In July, 1914, a practical glass maker was added to the force of the Bureau. He is a college graduate of scientific training but skilled in the manipulation of furnaces, and is the sort of a man to make progress at the present stage of the work.

Small furnaces were built and melts of a few pounds of ordinary glass were made in order to become more familiar with the technical side. A larger furnace has just been completed which will handle melts of 25 to 50 pounds. The Bureau is now making simple glasses according to definite formulas, studying the methods of securing it free from bubbles, and other practical points. This is to be followed by an investigation of the method of annealing.

Several glass manufacturers have visited the Bureau already for suggestions as to equipment for the manufacture of optical glass.

REPORT OF AN INVESTIGATION OF HIGH SCHOOL PHYSIOGRAPHY.[1]

By Charles Emerson Peet,
Lewis Institute, Chicago, Chairman of Committee.

The impression has been abroad for some time that high school physiography is on the decline, that it has failed to make good and is either being displaced by other subjects or the course is being shortened to make place for other subjects. Your committee was appointed to ascertain the facts. The first effort of the committee was to learn how many schools have dropped the physiography in the last few years. Correspondence with the State Superintendents of Public Instruction of Iowa, Minnesota, Wisconsin, Michigan, Illinois and Indiana, brought out the fact, that with one exception, there are no statistics in their possession bearing on this point. From the Minnesota superintendent we learn that the number of high schools in that state offering physiography have been practically constant in the last four years. Without taking a census of the high schools by mail, we have seen no way of getting the complete facts. In Iowa, Miss Alison E. Aitchison, a member of this committee, examined the entrance credentials filed by 473 students, representing more than 250 Iowa high schools and found that only 32 did not present physiography as an entrance credit. It is the opinion of one of the geologists of the University of Iowa that physiography is being replaced by general science, and by agriculture and biology, but that the change is so recent that it does not yet show in the entrance credentials.

As another possible source of information letters were addressed to the principals of 161 high schools, in the states mentioned, which have recently adopted "Clark's General Science" as a textbook.

The committee received replies from forty-eight schools. Thirty-four of these schools offer a course in physical geography, and five in general geography. In nine schools physical geography has been dropped. In its place seven have substituted elementary science; one manual training for boys and physiology for girls; and another elementary science and general geography. In five of the thirty-four schools now giving physical geography the course has been cut to a half year, and elementary science introduced; in four schools physical geography has been moved to a later year by the introduction of elementary science.

[1] Read before the Earth Science Section of the Central Association of Science and Mathematics Teachers, November 27, 1914.

WHY ELEMENTARY SCIENCE IS DISPLACING PHYSIOGRAPHY.

Some of the reasons given for these changes are as follows:

1. "We feel that elementary science is much better adapted to interpret, broaden and enrich the experiences of first year pupils than is physical geography. Nearly all the essential principles involved in the study of physical geography are developed in their elementary form in elementary science, and the pupil gets possession of other principles and laws which illuminate his common experiences in a way that physical geography can scarcely approach. Physical geography would prove very interesting after elementary science, but first things should come first, hence the change; our results are much more satisfactory since we made the change."

2. "We have discontinued our physical geography in the freshman year and put it in our junior year. In its place we have put elementary science. The texts in physical geography were too difficult for Freshmen. The Juniors are doing good work in physical geography and are enjoying it."

3. "Elementary science provides a better basis for work in agriculture. Our high school offers an agricultural course only."

4. "We felt that elementary science fitted in better with our work in agriculture."

5. "General science more fully meets the requirements of the pupil."

6. "The needs of domestic science and agricultural courses were the reasons for making the change from physical geography to elementary science."

The facts gathered do not show the marked falling off in the physiography that would be expected, considering that the information comes from schools which have recently introduced a subject that is supposed to be displacing it. No attempt was made to discover to how great an extent agriculture is displacing the physiography, but this report can be considered no more than a preliminary report.

HAS PHYSIOGRAPHY MADE GOOD? VIEWS OF THE COLLEGE MEN.

It was one of the tasks set the committee to ascertain to how great an extent the impression, that "physiography has not made good" in the high school, is true. It is also a part of its work to ascertain the reasons for poor results, if the results are poor. It happens that the chairman of your committee has for some time been in possession of a considerable amount of data gathered by a committee for the North Central Association of Colleges and Secondary Schools, bearing on this question. A questionnaire

was sent to the instructors in earth science in the Colleges, Universities and Normal Schools of the northern states. Replies were received from fifty-five. To the question, "Do you find that the results in the high school physiography are such that the college courses in physiography and geology can be built on the foundation laid in the high school, or is it necessary to rebuild the foundation?" there were fifty-two answers. Forty-one say that it is necessary to rebuild the foundation.[2] In four cases the high school foundation in physiography is recognized by placing students with credit in this subject in a separate division of the college classes from those who have not entrance credit, while in a fifth case students with entrance credit are permitted to enter a class in advanced physiography to which, however, others are admitted who have not this entrance credit, but who have had other high school science. In addition, six indicate that the high school foundation might be recognized by placing some of the students who have had the subject in high school in a separate division, if the numbers were large enough to make a class. One instructor would make the basis of division scholarship rather than entrance credit, for, he says, "Those who have never studied the subject often excel those who come with entrance credit."

One instructor says, "It has been my experience that a student who has never studied either physiography or geology is very apt to do as well or better than one who has had both in high school. Of course, geology is the basis of modern mining engineering, and our students have four years of it, so we are probably more critical than would be the case if we were teaching non-technical students, but I am very sure that we cannot at the present time afford to differentiate between those who have and those who have not had courses in physiography or geology in high schools, except in very rare and unusual instances.

"Of course, I do not mean to infer that good teaching is unknown in high schools. I am sure that many instructors are doing first class work,[3] but we have found in that case it does no harm for a student to review these subjects, if he is mature enough to realize their value and importance. If he is not mature enough to understand this, it is best for him to fail and repeat the work until the truth is borne in upon him.

[2] Let those high school instructors who doubt the necessity of this rebuilding, test, in an informal way, their own students, one year, two years and three years after the completion of the physiography course, and keep a record of the results with good students and also with poor students. The committee would be glad to receive reports of the results of such tests.

[3] Another reply from the same state indicated that there were four high schools in the state that were doing good work in physiography.

"As far as we are concerned, then, there is no such thing as preparatory work in geology and physiography, and, if we were the only school involved, high schools could plan their courses without a thought that they were preparatory in any sense."

Another says, "My class in freshman geology usually consists of about 120 boys from all kinds of high schools, some with supposedly good courses in physiography, some with poor ones, and some with almost none at all. So far as I am able to judge from the lectures and frequent quizzes which I give them, those from the schools with the better courses have no advantage over the others."

Another says, "The foundation is as good probably as the foundation in any other subject pursued in high school for the same length of time. For example, half a year in algebra in first year high school is not a very sure foundation for mathematics. My experience shows that the high school text and teaching lays a good foundation for further study of such a book as Salisbury's college text. Our young pupils who have had a *brief* course in elementary science are better prepared for physiography than they would be otherwise. I have had experience with physiography after physics only in a few individual cases. These take Salisbury's college text very well without having had more elementary work."

In reply to the question: "In your experience has the high school laboratory work in physiography made the student appreciably better able to meet the entrance requirements in the subject?" nine answer, "No"; six answer, "Yes"; eight answer, "Yes, more or less helpful" or express some doubt of the helpfulness. Five do not know what the effect of the laboratory work has been; seven report students have had practically no laboratory work.

To the question: "Do the results justify the opinion that the high schools have the right things for laboratory work?" two answer "Yes;" seventeen answer "No;" five don't know, and one answers, "Some things are, and some are not."

Comparison of Results in Physiography Preceding and Following The Physical Sciences.

To the question: "Do you notice any difference between the results produced in schools where the physiography precedes the physical sciences and those where it follows them?" twelve answer "Yes" and some of these say, a great difference. Six

answer, "No." Sixteen do not know. Eleven say that physiography should never precede the physical sciences in the high school course. Five mention superior results where a course in general science has preceded the physiography.

Results in High School Science Compared.

To the question: "In your judgment how do the results in physiography compare with those in botany, zoölogy, physics, and chemistry?" seventeen answer that in physiography they are inferior. Four more say that they are inferior to the results in physics and chemistry, but equal to those in botany and zoölogy; one says that the results are inferior to those in botany with girls and in physics with boys. Eight answer that the results in physiography are equal to, and four that they are superior to those in the other subjects mentioned. Eight answer that they do not know, or that comparison is impossible. Other answers are: "The results are less definite but no less in value." "The value is greater on account of the greater value of the subject, but ordinary examinations would suggest a contrary conclusion, for physiography is not as well taught as are the other subjects." "The results are as permanent as those in the other subjects."

Tangible Results of Physiography in the High School.

In reply to the question, "What tangible results do you observe have been produced by the high school physiography?" eleven answer that no tangible results have been observed. Other answers are as follows:

1. "Most of the high schools in this state give a course in the first year which is intended to be an introduction to scientific methods of observation and reasoning. As the students have no foundation to build on, they do not really gain much, and so do not apply the little they do gain, and it does not stay with them. The course is usually taught by whichever instructor happens to have the least regular work on his schedule, without any regard to his fitness or preparation. Hence the net results are usually small; quite as often as not, they are actually negative. Frequently the student is given a distaste for science in general. A well selected course in general science taught by a specially trained instructor would give much better results.

"There are a few schools where the subject is well taught and good results are secured, but when the pupils are twelve to fourteen years old, as they usually are in the first year of the high school, the instruction given can hardly be called instruction in

physiography. A few schools do really good work with their seniors in courses which emphasize and correlate the principles learned in the other science courses and so help to fix them."

2. "On the whole the results have been beneficial, but not commensurate with the time spent because of the teacher's general lack of preparation in geology."

3. "Where the teacher has been a good one, a great deal has been done to make the pupil think about processes going on around him. With a good teacher much interest has been developed and the work is excellent."

4. "High school physiography in so far as it is handled by specially trained teachers has been markedly successful and has supplied new and useful ideas in great numbers and more than any other subject. But the result is not apparent in cases where the music teacher or the teacher of English Literature or any other unqualified person is assigned the work in physiography. The day has passed when 'any old person' can handle physiography."

5. "I have spent considerable time in investigating this problem in Iowa, and I think I can say that a considerable interest in the subject has been developed, and one that is educational. This, I find, varies with the conditions under which it is taught."

6. "As a rule an interest is developed. In individual cases I have found the opposite."

7. "I rarely find a student enthusiastic about the subject; as a rule students are indifferent to it."

8. "When high school physiography is well taught we get good results. Well taught students want to go on with the subject. They find it helpful in history, economics, and geology."

9. "General appreciation of earth sciences."

10. "Renders the student better able to cope with general geology and stimulates an interest in natural science."

11. "In the few instances under my observation, a firmer grasp of geographical problems is the result."

12. "Makes better teachers in geography."

13. "The mind has been opened to view large things and to view small things in a large way."

14. "In a few high schools where the teachers have had special preparation for their work, I find that the pupils have acquired a well organized body of facts."

15. "The results stand second to none as a first year high school subject. Give it a full year with an enthusiastic teacher

and you put the boys and girls in touch with more valuable notions about the common things of life in broad outlines than is possible in any other subject. Pupils like it. They have their eyes opened to a helpful interpretation of the common things about them. They enjoy their walks, excursions, and travels better. They see and appreciate relationships among wind belts, rainfall, vegetation, and population and industry."

16. "Doubtless there are results, but these are not tangible except in an occasional student. I sometimes think the poor work of students (some of them) having previous preparation may be in part due to an attempt to slide through on what they have retained of the past work, coupled with a spirit of rebellion at having to do this work over again (though they can make little progress unless they do)."

17. "Occasionally a man enters my classes, whose interest has been aroused by his course in physiography, but it usually takes the form of a belief that he has learned all that is to be obtained."

18. "Usually the only tangible thing in evidence is a superficiality and conceit of knowledge. The exceptions are individual."

19. "I am not prepared to speak positively, but it is my opinion that because of the usually poor preparation of high school teachers for teaching physiography, it does more harm than good."

In answer to the question, "Has an interest in the subject been developed, or has the result been just the opposite" twenty-five indicate that "more or less interest" has been developed. Three report the opposite; eleven report interest with some, and the opposite with others.

(*To be continued.*)

THE USE OF LAND IN TEACHING AGRICULTURE IN SECONDARY SCHOOLS.[1]

By Carl Colvin,
Blackburn College, Carlinville, Ill.

In discussing this topic I wish first of all to classify the secondary schools into the following categories:

(A) The high school of the city having no land or very little.
(B) The township high school having a medium plot of ground.
(C) The high school having access to or owning a large farm.
(D) The academy operating a farm.

As to the distribution of the various classes a report given by Mr. Lane of the Department of Agriculture says that from a list of a thousand high schools 257 or about 25 per cent have some land; 52 or 5 per cent have farm animals. Half of those who possess land operate farms of less than three acres; 150 farms grow corn in some amount; 61 grow alfalfa. But gardening in some form seems to be the most important work.

In the first place let me say that from my own experience, and from the experience of others with whom I have been able to communicate, I do not believe that land can be utilized to an economical or educational advantage unless an agriculture instructor is kept at the school through the entire year. In some instances someone who is not doing teaching work is kept on the land and the plan seems to work successfully, so in the discussion of the several classes we should assume that someone is always on the job.

The city high school of today does not possess very much land as a general rule. This is probably due to natural factors. First, the city high school which was built years ago needed no land because agriculture was not then a part of the regular curriculum. Secondly, the modern high school which is being built in the city must necessarily be built in crowded parts in order to accommodate most advantageously the entire population. Where control of land is possible the use to which it is put will depend largely upon local conditions. If there is but a block of land it will be more profitably used for landscape purposes than for economic gardening. Lessons of sanitation, cleanliness, beauty, ethics and civic pride may all be taught, not only to the pupils but to the public as well, by contrast of such plantings with a nearby vacant lot. I

[1]Read at the November, 1914, meeting of C. A. S. & M. T. held at Hyde Park High School, Chicago.

find that boys living in the slums of our large cities take an especial pride in their respective school yards where landscape art is in evidence, which is not done where the school yard has no trace of plantings.

If there is enough soil, vegetable gardens may well be put to practice. The problem of care in this instance will probably fall to the janitor for solution. If not the janitor, the instructor must bear the responsibility, or a gardener will have to be employed. The latter would not be practicable unless gardening was carried on on a large scale. Classes may be utilized in preparing the soil and planning gardens and in planting the seed. These operations will make excellent laboratory exercises for high school classes in agriculture. But seldom can we depend upon the boys to care for the garden through the summer unless they have a monetary interest in it. This is not so practicable in the large city because the high school is often quite a distance from the homes of the boys. The high school boy often works during the summer months and will necessarily neglect the school garden. However, the greatest success has been found in such instances to come from demonstration work. The garden is made a model garden and cared for by some one individual who is paid for his services. In this way, the garden may be practically ideal and men will take note of it as a lesson worth while. One possible solution for the care of the garden is to give some boy anxious to make some pocket money the full control of the entire school garden and pay him on a percentage basis. A second feasible solution is for the instructor to remain through the summer months and either care for the garden himself or organize summer classes among the boys using the garden as a laboratory.

The high school which has a medium plot of land—from one to three acres—as more than half the schools having land probably have, will have a better opportunity to do some demonstration work in the community. There will be room for a model garden. Here is offered an excellent opportunity for outlining what might be done on a definite area. It will not only serve as a lesson to the students but can be made to serve the public as well. The garden should be about the size required for an average family and should contain everything which can be grown economically. There are a number of plans for such gardens available which have been worked out from experience in different localities, and the plan which an instructor will adopt, naturally, must depend upon the locality in which he is working. We have such a garden in con-

nection with our school and are able to utilize the plan very effectively. Of course we need much more than a garden will supply as there is a dormitory in connection with the school but I find it better to run this model garden of average size, and to utilize large patches as a source of supply for the dormitory.

Then there is ample room for a home fruit garden in three acres where new and desirable varieties of fruit may be grown for profit. Frequently communities in this section of the country become attached to varieties of fruit—Ben Davis and Jonathan for instance—and are loath to try any other of the varieties to be found in the cosmic enumeration of catalogs. Oftentimes we can profit by introducing new varieties. My class in agriculture planted an orchard last Spring and in it placed ten good varieties of apples beside several varieties of the smaller fruits. We hope to have an orchard that will not only prove to be well balanced in variety but one that will serve us through the entire season and for all purposes. This idea will provide for laboratory work when the study of horticulture is taken up. I find it most profitable this Fall to take my class in horticulture to our own orchard and pick out illustrations of theories presented. We make use of neighboring orchards for this purpose but with our own trees we may do as we please, thus making the laboratory work more satisfactory.

The disposition of the garden and orchard products would necessarily be left to the attendant. If he be the instructor in agriculture so much the better. If he be the janitor of the buildings, he will not only have employment but will have some means of getting the good home product for his own table.

The third class is perhaps the most important though there are fewer high schools in this category than in any other. If there is a farm of 60 or 80 acres or more in connection with the school it will, of course, be necessary to hire enough help to take care of the farm outside of the students and the teaching force. We may depend upon student help during laboratory periods to some extent but experience teaches that laboratory work on the farm does not always give economical results though it be free work. Such work as preparing the soil and planting the garden may be done by students. Picking fruit in the fall may be made laboratory work, or students who are in need of financial aid may be given work and paid by the hour. The small fruits ripen during vacation; the plowing must be done by one man; the team must be kept busy; the corn grows during vacation and must

be cultivated at that time. The vegetables which the class so eagerly, and perhaps faithfully, planted in the spring are growing and maturing during the summer months when lessons could be taught if the boys were only there. Practical experience brings us to the conclusion that we can expect little actual help from the students hence the farm, no matter how large, becomes a demonstration project.

But as such there is a place for it in the secondary school work if it is run on a paying basis and a profit can be obtained either for the school or for the man who runs the place. It will furnish excellent means of supplementing class room education with the practical results. The farms should be operated, not with the idea of showing the difference between "manure and no manure," or between "limestone and no limestone," but with the idea of producing all the profit possible from the care of the soil.

This leads to the discussion of plot culture work. So far as I have been able to determine there are very few instances of valuable experimental stations in connection with secondary schools. The State Experimental Stations throughout the middle West are so distributed, and the data is so available, that there is very little need for further experimental work. Furthermore, the high school cannot afford to maintain the staff of experts which is necessary for continuing the experimental work. There will usually be ample opportunity for comparison of results between the school farm and some neighbor's farm to show the value of scientific farming. If the school grows alfalfa and the patron does not the latter will be asking for results and instructions. He will likely compare them with the results of his efforts in raising corn. If the comparison is favorable he probably will try alfalfa next season. By making the farm pay we can serve as great a place in the community life as by running experiments. I find the most common objection to experiments, even from farmers who see results weighed over the scales or planting in the field, is that it does not pay to bother with such methods on a large scale. But when someone farms and makes a decided success of the business then men take note and make similar efforts. I have charge of a farm on which the State operates an experiment station. We are growing alfalfa in a field across the fence from the station plot. We also grow corn, soy beans, vegetables, etc., on our part of the farm. The community is more interested in the success or failure of our efforts to make crops pay than they are in the difference between plot two and plot three on the

station farm. This is no diatribe against the station work but goes to show the natural trend of the "mind of the mob." So I contend that there is ample room for a farm in every county that is operated on a strictly economical basis and at the same time is managed by an expert who can intelligently put to practice the theories of the scientists. If this farm be in connection with the high school it will serve as a laboratory for classes in agriculture and as a demonstration lesson to the public.

The fourth class of secondary schools is a peculiar one as most of our academies are not supported by the public but by private enterprise, or by churches, or by endowment of some kind; but it is an important factor in the secondary education of every state. There is more justification for farms in connection with academy schools. If the farm can be operated by the instructor, or under his direction, it will fulfill two purposes. It will furnish a means of teaching agriculture and will be a source of revenue, for the treasury which is usually low in academy schools. It will also serve the community in the same manner which has been designated in connection with the high school. As to the problem of labor, students may be used where there are enough available boys who need financial aid and who are willing to work for a small wage. Student labor is not as valuable as the labor of ordinary workmen because the students will not accomplish the results on the farm, no matter how efficient they may be in their class room work. I shall not take time to discuss the many factors which enter into this phase of the problem such as light weights, aversion to work, lack of experience, lack of personal responsibility, lack of interest in the results to be obtained, shifting work, non-efficient bosses, etc. But all these factors, and more, contrive to cut down the value of the student labor. At our own school we require three hours daily of manual labor from each student. This is a part of his contract with the school and he must do that amount of work or he is checked up as not having paid his dues. This is rather a unique plan—the self help institution where a student may go to school not for less than he can go elsewhere but where an opportunity is given him to work his way at profitable labor. There are many problems yet to be solved in the handling of student labor even where they owe the school the work. Some of these difficulties would be eliminated if the students were getting paid in cash for the work done.

ILLUSTRATIVE MATERIAL FOR BIOLOGY COURSES IN HIGH SCHOOLS.

Your committee, appointed to make recommendations as to the illustrative materials with which high schools should be supplied in order to give in a satisfactory way the courses in Botany and Zoölogy, beg to make the following report.

1. We desire to express our conviction that every school should, regularly and with some system, undertake to build itself up in this regard. By following this practice through a period of years any school may supply itself with the minimum necessities, without financial strain.

2. It is possible, for convenience, to divide the illustrative necessities into two main groups: (a) Those that must be purchased outright, and (b) those that may be made gradually by students of successive classes, if only they are supplied with the necessary raw materials. This latter class is somewhat larger than we may at first sight believe. Furthermore, whenever it is possible for some such materials to be made by students the very making may become a means of increasing interest and of giving fuller meaning to the course.

3. We desire also to insist that most teachers do not use, as fully as they should, the supply of illustrative material which nature affords. The individual work in fields and forests, in swamps and in the waters, in parks and gardens, in greenhouses and zoölogical gardens furnishes a means of illustrating courses which our formal use of the laboratory and class room cannot at all replace.

4. In detail we make the following suggestions as to what should be held in the mind of the teacher of biology and the directors of schools as objectives:

a. *Museums.* Small synoptic collections illustrating the main phyla and classes of the animal kingdom and the main groups of plants are very valuable. These should not be large and should be built up by successive classes, teachers, and friends of the school rather than got by purchase. Money should go into the cases, containers, and preserving materials, rather than into specimens. Some specimens as sponges, corals, and other sea forms may well be bought. Aside from such synoptic collections, built up by successive classes, two particularly interesting lines of addi-

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The report of a committee appointed by the Biology Section of the High School Conference of the University of Illinois, Adopted Nov. 20, 1914. The Committee: T. W. Galloway, Millikin University, E. N. Transeau, Eastern Illinois Normal, and Clarence Bonnell, Harrisburg Township High School.

tion are open to high schools: (1) considerable numbers of certain kinds of objects (e. g. snail shells, or leaves, or insect species), arranged to illustrate the *range of variation*, may be mounted for display; and (2) skeletons may be prepared and mounted, or other specially excellent dissections by members of a class may be preserved. Such original contributions by students may well be labeled and credited to the student preparing them. Such a museum does not need to be large to be exceedingly valuable; but it should be fairly representative and synoptic.

b. *Living materials, plant and animal.* There should be some greenhouse facilities, if only a sunny window, for winter use, and outdoor beds for spring, for first-hand supply of botanical material. A corner in the local greenhouse can often be rented.

There should be one aquarium of some size, if possible with running water. A number of battery jars or other glass vessels of various sizes, insect cages, life-boxes, and the like are essential. Students can make many of these boxes and cages, and even small wooden aquaria with one or more glass sides. A small fund should be available for such purposes, and be available without unnecessary delay. All these things are valuable to insure having organisms when they are needed, to allow experiments and continued observations on habits, and to allow study of development. The library should have at least one good book containing suggestions for making such apparatus and for the care of living material. If the schoolroom is not kept heated at night these life supplies may be kept in a suitable basement room during the coldest weather.

c. *The local collection of living material.* We feel that something is lost if classes are not encouraged to collect as much of the needed local material as possible for themselves. Field work should be so organized that at least some of this shall be done. In connection with this sort of work a home-made map, drawn to suitable scale, of the locality for several miles around the school may be perfected, if the locality at all lends itself to this treatment. All important topographic points that have to do with plant and animal life should be located. The roads, streams, springs, ponds, and other special habitats of specially interesting plants and animals should be indicated. There should also be a card catalog or indexed book in which are inserted the localities on the map where special types of plants and animals are discovered from year to year. In a few years such an arrangement will illustrate some of the local facts of geographic distribution,

as well as be an aid to each incoming class in finding what it needs. It will be necessary always to purchase some materials for laboratory and museum work. We cannot publish a complete list of dealers; but the following are reliable:

A. A. Sphung, North Judson, Ind. Live or preserved frogs, crayfish, turtles, etc.

H. M. Stephens, Dickinson College, Carlisle, Pa. Zoölogical and botanical materials for class use.

C. S. Brimley, Raleigh, N. C. Reptiles, amphibians, and fishes, living or preserved. Good for late fall or early spring orders.

Biological Supply Co., 106 Edgerton St., Rochester, N. Y. Plant and animal materials for laboratory; slides.

Marine Biological Laboratory, Woods Hole, Mass., preserved materials for Botany, Zoölogy and Embryology.

Saint Louis Biological Laboratory, St. Louis, Mo. Microscopic and lantern slides.

d. *Microscopes.* If microscopes are used only for demonstration purposes there should be at least two good standard instruments with powers ranging from 50-500, so that both low and medium power views can be shown at the same time. There should also be one oil-immersion objective for occasional high power demonstrations.

If microscopes are to be used as a regular part of the laboratory work, as we feel they should be, there should be *at least* enough to supply each pair of pupils in the largest section with one complete, standard instrument. We believe that no laboratory section in biology should contain more than 24 members for one instructor. Twelve microscopes can be made to serve such a section.

There should be a simple dissecting microscope for each pupil or each pair of pupils.

e. *Microscopic slides.* These may be divided into four groups: (1) temporary slides, which teachers and pupils may make freely. The teacher should become expert in making these and enabling his pupils to do so; (2) permanent mounts of interesting objects small enough to be stained and mounted whole. There are very many such which are valuable. It should not be necessary to purchase these. The teacher should be supplied the necessary materials and learn to make, stain, and mount these; (3) temporary or permanent mounts where free-hand sections may serve all necessary ends. The teacher should be able to make,

stain, and mount these; and (4) permanent mounts of materials where expensive apparatus is necessary for imbedding, sectioning, grinding, etc. These can be bought much more cheaply than made, and the apparatus necessary to make them is hardly to be sought in the ordinary high schools. We append a suggestive list of especially valuable microscopic slides that should be purchased and used at least as demonstrations in high school courses. These should be the best of their kind,—clear, typical, and perfectly stained. Taken in connection with the simpler slides that may be made in the laboratory, this list can be made to illustrate many of the more important microscopic problems of the course.

1. Cell structures, cell-arrangement, and cell-division as seen in longitudinal section of root tip of *Tradescantia* or *Hyacinth.*

2. Cross-section of leaf, showing structure of this basal organ of all nutrition.

3. Cross and longitudinal sections of monocotyledonous and dicotyledonous stems.

4. Cross-section of a root.

5. Cross-section of ovary of lily or other suitable plant, showing relation of the parts.

6. Longitudinal section of young flower bud or leaf bud showing the beginnings of floral parts, or the foliage units.

7. Section of anther showing pollen-formation.

8. Longitudinal section of pollinated pistil showing pollen tubes, etc.

9. Some properly stained bacteria,—as *Spirillum, Bacterium, Bacillus,* etc.

10.. Sections of hymeniun of Ascomycete and Basidiomycete.

11. Cleavage, morula, and gastrula stages of some form like the starfish.

12. Sections of tadpoles of 1 to 3 weeks to show how animal cells come to be related in tissues and organs, as well as the relations of the organs. Good to compare with (1).

13. Cross and longitudinal sections of *Hydra.*

14. Section through vertebrate eye in visual axis.

15. Section of compound eye in axis of ommatidium.

16. Longitudinal and cross section of bone.

17. Longitudinal section of tooth.

18. Cross-section of stomach or intestine, showing coats, glandular-absorptive surface, etc.

19. A Golgi preparation showing ramifications of neuron.

20. Section through skin of mammal.

21. Section of injected liver.
22. Ciliated cells.
23. Cross and long (several segments) sections of earthworm.

f. *Projection apparatus.* We believe that a projecting lantern with opaque projector and a projecting microscope should in time be provided for each high school. The usefulness of such a lantern would not of course be confined to the department of biology. This would demand also the gradual accumulation of a limited number of well selected lantern slides and microscopic slides.

g. *Illustrative books.* So much success has attended photography, both gross and microscopic, and the reproduction of these pictures in books, that every school should supply itself with some books illustrating natural history to aid in identifying the plants and animals discovered by the classes and in visualizing such as the student may not be able to find in his own locality. Under this head come illustrated natural histories, flower-books, bird-books, butterfly books, the reptile book, and the like.

h. *Charts.* Very effective charts for both botany and zoology are issued by a number of firms. These are valuable, but expensive. Each school should perhaps have a limited number of these charts illustrating certain features of life not readily illustrated in some other ways.

Of even more value, however, in some respects are home-made charts, drawn from figures and tables in books and periodicals. They may be made on paper or on paper reinforced by cloth. They may be mounted on a roller or kept flat. Ingenious devices to display them can be made by the pupils themselves. Ink may be used, put on with a brush, or colored crayon may serve. A spray of shellac, from an atomizer after the crayon marks are made, will keep the crayon from spreading. There is almost no limit to the number of charts,—of lines or simple shaded surfaces,—which classes and teachers may make by copying figures from books, nor to the help they render in making structures clear.

i. *Blackboard drawings as illustrative material.* The committee desires to emphasize the importance of the ability of the teacher to make simple free-hand diagrams before the class. Every teacher should give time to cultivate this power to his full capacity, and to use whatever drawing ability the members of the class may have. These should not be made too complex. They are valuable because of their simplicity and the consequent emphasis on essentials, and on the fact that they grow under the eyes of the pupil.

THE BIOLOGIC POINT OF VIEW.

By Arthur Galette Clement.

Inspector of Schools. The University of the State of New York, Albany.

One of the aims of an elementary course in biology is to give students some understanding of the essential functions carried on by all living things. When students comprehend this aim, they realize that they are studying biology and not three separate subjects, physiology, botany and zoölogy. They perceive how the different phases of the science are unified, and acquire the biologic point of view.

Paradoxical as the statement may seem, the teacher with the best university training is sometimes unsuccessful in giving instruction to first year high school students because he uses too fully the inductive method. By endeavoring to conform too closely to this method, he fails to secure the immediate interest of his students and does not make clear to them the unity of the subject.

In teaching biology to students in the first year of the high school, any instructor will find it advantageous to employ at the beginning of the course the vocabulary already in the minds of the students rather than to introduce the subject by the use of some topic like the structure of the cell, which requires knowledge of new terms; and he will undoubtedly meet with more ready response on the part of the students if the experimental work is begun with objects familiar to them rather than with a series of unfamiliar structures.

At the beginning of this study much time may be gained by ascertaining what physiologic facts the students have already acquired from observation of their own bodies and from their own experiences. This implies that the study shall begin, not with microscopic examination of protozoa and algae, but with the object with which the students are most familiar, the human body.

An elementary course in biology is best approached by placing emphasis on function rather than on structure. Young students will grasp the idea of function much more readily by observing as far as possible the physiologic processes of the human body, than by considering the properties of protoplasm.

If students have been properly instructed in physiology during their grammar school course, they will already know the meaning of the word function and will be able to name the essential

functions of the body. Unfortunately, however, owing to the desultory instruction given in physiology in pre-academic grades, the majority of students are not able to mention all the essential functions necessary to life. Let any teacher who doubts this ask the members of his class to enumerate these and I think he will be convinced of the accuracy of this statement.

First, then, students should learn as much as possible about the functions necessary for daily life by the consideration of the life processes of the body. If skilfully directed and questioned by the teacher, they will discover the following: motion, respiration, circulation of blood, excretion and sensation, all physiologic phenomena. The nature of absorption and of digestion can be shown by experiments, and the idea of assimilation taught deductively. If reproduction, which is necessary for the continuance of the race, is added to this list, the students will have in mind the essential physiologic functions of the human body. They will call this study physiology.

The study of an animal, preferably a frog, should then be carefully made. In this study the fact that its life functions are the same as those of the human body should be developed as the various parts are examined and their similarity to organs of the human body explained. The students will call this study zoölogy.

The study of the animal should immediately be followed by the study of the plant as a whole, e. g., a bean seedling. In this study the students should learn by experiments, as far as possible, that the life processes of the plant are similar to those of the frog and of man. The students will call this subject botany.

The skilful teacher never neglects to base his instruction on knowledge already acquired by the students. The latter know that plants as well as man and animals require food. They know also that plants make food for man and animals, but they do not always understand that green plants make the food for their own use and store it in seeds, leaves and roots.

By simple experiments students are easily convinced that plants show motion and sensation in response to light. Some have already observed in the field or the garden that plants have these attributes. By other experiments they may be shown that plants use oxygen and excrete carbonic acid gas in respiration. The excretion of moisture is also easily demonstrated. The experiment to show the movement of fluid as it rises in stems always interests students. The fact of reproduction they never question. All have probably sown seeds and observed their growth.

In the germination and growth of seeds the stored food is digested, absorbed, passed from cell to cell and assimilated. Thus nutrition is accomplished in plants the same as in man and in animals. These facts should be explained and, as far as possible, made clear by demonstrations.

The time has now arrived when the teacher should explain that, since the functions necessary to life are the same in plants, animals and man, the subject matter discussed is really all one study, namely biology, this word meaning a discourse on life.

The following table will give a graphic representation of the discussion suggested:

		Biology		
		Physiology (Study of man)	Zoölogy (Study of animals)	Botany (Study of plants)
Functions		Motion	Motion	Motion (limited)
		Sensation	Sensation	Sensation (irritability)
		Excretion	Excretion	Excretion
		Respiration	Respiration	Respiration
		Reproduction	Reproduction	Reproduction
		Food-taking	Food-taking	(Green plants make their own food and store it)
	Nutrition	digestion	digestion	digestion (of stored food)
		absorption	absorption	absorption
		circulation	circulation	movement of fluid (circulation)
		assimilation	assimilation	assimilation

If a teacher will develop a table similar to this one by the study of a frog or other higher animal and by the study of some common plant in comparison with man, emphasizing the idea of function, he will have little difficulty in establishing the biologic point of view in the minds of his students and will have the pleasure of seeing them grasp the idea of the unity of the living world comparatively early in the course of study.

ALUMINUM FROM CLAY.

Though new bauxite deposits are being found from time to time, there is considerable interest in the preparation of pure alumina from clay or other silicate minerals. As soon as a process for the extraction of alumina from clay is put on a commercial basis, large quantities of low grade bauxite containing considerable admixtures of clay will become available as aluminum producers. According to the United States Geological Survey there is a large tonnage of such material associated with most of the southern Appalachian bauxite.

ADDRESS OF WELCOME TO THE NEW SECTIONS OF HOME ECONOMICS AND AGRICULTURE IN THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

By Otis W. Caldwell,

University of Chicago.

It is peculiarly fitting that these two sections should be organized in this association at the same time. They stand, each in its own field, for the same point-of-view in education, a point-of-view recognized and utilized to some extent in our other sciences, but definitely focused in Home Economics and Agriculture.

Throughout the twelve years covering the history of the Central Association of Science and Mathematics Teachers, its constant purpose has been the improvement of the use of science in education. During this period science in the schools has undergone considerable change in the subjects presented, and in the content of those courses which were formerly offered; but most of all, the change has to do with what we think science teaching should accomplish in secondary education.

The extension of science in the world of affairs has outrun science in education, partly because of the tremendous demand in affairs for the things which science could contribute, and partly because persons engaged in science teaching were slow to realize that education for participation in the thoughts and activities of men is the only real education. We believe in the spirit and method of science as the spirit and method by which we discover new truth, or rediscover old truth, or by which we are enabled to meet our daily problems in a just and efficient way; but this spirit and method help to educate young persons only as they affect the things which these persons do. We are educated through and by our work, to the end that our further work is more effectively done. Any system of science teaching which does not look toward improvement, both in the rationale and the practices of real work, is open to serious question. Any scientist who takes pride in the fact that his work is wholly apart from the work of the world is likely to have few students who desire to share in that pride for people are coming to believe in a dynamic and not a static education.

Practical education in science does not find its chief nor its real foundation however in the fact that it brings a valuable tangible return to the student in the form of a better livelihood,

but in the fact that by furnishing him a dynamic purpose for working, he works more intelligently and is educated thereby. Practical education is for better education primarily, and only secondarily for better productivity in the results of work. Agricultural education is for the farmer, not for the corn crop; home economics is for the housekeeper, not that there may be better bread. But when the farmer is poorly educated in ideals, in intelligence, and in practice, his farm evidences that fact by its poor corn crop. When the housekeeper's work fails to receive the care of an intellectualized person or a trained hand, the bread, with its sodden weight, seeks the level of its maker. Real education in science means better productivity. Since the worker himself is improved, his work is improved. If we have better people we shall have better products.

To the young person, however, the process of his own education is one of which he is unconscious most of the time. His attention is upon his work, objectively, not upon his education, subjectively. He is often conscious of his work and of the things that he needs in order to do his work in a better way. In so far as he is conscious of his own education, it is in terms of his better ability for his work, not in terms of his education subjectively, or abstractly. Real work has a dynamic and compelling quality which science must utilize much more extensively if it is to be of the highest educative value in the lives of young persons.

We especially welcome these two new sections which will consider these two distinctly practical phases of our science education. We trust their respective fields—home economics and agriculture—will be regarded as types of science education primarily for better educated men and women, knowing that better homes and better farms are merely the exponents of a better educated people.

DELAWARE ONCE AN IRON PRODUCER.

In colonial times and during the early years of national life Delaware was of considerable relative importance as a producer of iron ore for bloomeries and forges, but with the rise of the blast furnaces and the disappearance of the bloomeries Delaware's iron-mining industry ceased to exist, and no iron ore has been produced in the state for many years. The principal mineral products of Delaware now are obtained from quarries, sand and gravel pits, and springs of potable water. The value of the total mineral production increased, according to the United States Geological Survey, from $425,360 in 1912 to $541,542 in 1913.

REPORT OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS COMMITTEE ON THE UNIFIED HIGH SCHOOL SCIENCE COURSE.

At the meeting of this Association in 1913, in Des Moines, Iowa, your committee reported in favor of plans for a more coherent and more purposeful unification of high school science. That report included a statement of the "Present Condition of High School Sciences," a "Basis for Organization of Science in the High Schools," and specific recommendations regarding "The Course." The basis of organization was stated entirely from the point of view of the educational needs of high school pupils. These needs are:

1. High school science should give pupils such a knowledge of the world of nature as will help them to get along better in the course of everyday life.
2. Science can not help people in fundamental ways in everyday life without serving to make better people. The truths of science are the truths of life, and while one may for a time divert the verities of nature, the fundamental laws of science eventually correct these errors. While science, therefore, should enable people to get along better, it does so by improving the people through their improved attitude and intelligence in their work, and this means increased efficiency.
3. Science should stimulate pupils to more direct and purposeful activity and also should help them to choose intelligently for future studies or occupations. This purpose is common between science and other subjects of the curriculum, but may not be omitted from science because of the very large number of ways in which science is used in the world of affairs.
4. Science should give pupils methods of obtaining accurate knowledge, which method should assist in solving the pupil's own problems. It should develop an abiding belief in the value of accurate knowledge and the danger of dependence upon any other kind of knowledge.
5. Science, by giving pupils a greater and clearer knowledge of nature, should give them greater, clearer and more intelligent enjoyment of life.

It was further recommended that "The first year of science of the high school should be organized upon a broad basis involving fundamental principles of the various sciences and using materials from all, if needed. . . . The important subject of physiology and hygiene should be combined with physical education." It was recommended that in the second high school year "Emphasis should be placed upon the biological sciences and their applications," since "The life sciences and their physical basis are fundamental to a scientific understanding of the world's food, clothing, shelter and commerce," and to an understanding of "the significance of life upon the earth and of the relationship of living things"; also the life sciences are fundamental as "a basis for personal and public hygiene, domestic science, agriculture and other vocational studies." It was recommended that in third and fourth years of high school there should be different radiating lines of science—domestic science, agriculture, physical and chemical science, and science electives.

This year's report of the committee, as was true of last year's report, must be a report of progress. Following last year's re-

port the committee formulated an outline of topics for first year science. This was used as a basis of discussion in several conferences, the last of which was participated in by thirty-three secondary school teachers coming from various schools including those of Gary, Ind., South Bend, Ind., Indianapolis, Ind., Normal, Ill., St. Louis, Mo., Madison, Wis., Milwaukee, Wis., Chicago, Ill., etc. In all these conferences the prevailing opinion favored the plan of first year science, as well as the general plan for unification of the four-year course. The prevailing opinion also favored withholding any adoption of any particular outline of a course, pending the results from many experiments upon reorganization now going on in various high schools.

It is obviously a more adequately scientific method of procedure in reorganization, to await the results of experiments now under way, rather than to ask adoption of detailed plans of courses which are formulated by the committee, or based upon the experiments of but one or two systems of schools. Several attempts at reorganization and unification are now being made, and other large organizations have committees working upon this question. Among these organizations are the North Central Association of Colleges and Secondary Schools, the National Education Association, certain State Associations and some of the large cities. There is extended interest in the question upon which the committee was asked to work and in the main the preliminary report of the committee seems to embody the principles and plans which are favored.

Your committee, if continued, proposes that further work be done as follows:

1. That each high school in which plans are now being tried in order to secure a unified four-year science course, be asked to furnish a statement of the general plan of procedure and the conclusions, if any, which have been reached, and the data upon which these conclusions are based.

2. That topical outlines and method of procedure be secured from type courses in first-year and second-year science and that comparative statements of these be prepared.

3. That data be secured from a large number of high schools throughout the United States, schools in which no special experimentation is under way, to determine whether in general school practice there are tendencies toward elimination of any of the science subjects, and thus a tendency toward unification.

4. That the results of 1, 2 and 3 be published, and made the basis of next year's report of the committee.

The report was adopted and by specific vote the committee was asked to continue its work as suggested in the report.

OTIS W. CALDWELL, *Chicago, Ill., Chairman.*
JAMES H. SMITH, *Chicago, Ill.*
C. E. SPICER, *Joliet, Ill.*
A. W. EVANS, *Chicago, Ill.*
W. M. BUTLER, *St. Louis, Mo.*

ROSENWALD HALL AT UNIVERSITY OF CHICAGO.

The meteorological tower of the new Rosenwald Hall at the University of Chicago not only is to have the complete equipment necessary for the usual observations of a meteorological station, but is so arranged as to accommodate additional appliances for special investigations as occasion may arise. The more conspicuous instruments are the anemometers and wind vane and the devices for measuring the temperature, pressure, and moisture of the atmosphere. All of these are provided with automatic registers which keep a continuous record of the atmospheric changes.

The platform for the seismograph is supported by a cement pier extending down to the solid rock about sixty feet below the campus surface. During the year two or three seismographs will be installed, for the reason that separate instruments are required to record the east-west, north-south, and vertical tremors that pass through the earth. Professor A. A. Michelson, head of the Department of Physics, has invented the essentials of a seismograph of a new type, and it is probable that this type will be perfected and installed instead of those already in use.

A special laboratory has been provided for experiments in the formation of minerals and ores under exceptionally high temperatures and pressures. As a precaution to minimize possible accidents this laboratory has been placed, not under the building, but in the space between Rosenwald Hall and Walker Museum.

In addition to these somewhat unusual features, the building is provided with more than the usual complement of laboratories for experimental and other research work in various lines, among which is a laboratory for experiments in dynamic geology in which artificial strata are formed and crushed under pressure to determine the laws of fracturing and folding in rocks. A series of experiments of this kind has been in progress for some time.

Unusual facilities for preserving and handling a library of about 75,000 volumes have been provided, as well as ample reading-room accommodation in close connection therewith.

This new building, devoted to the Departments of Geology and Geography, will be fully equipped for its work by the time of dedication at the end of the Spring Quarter.

SCIENCE QUESTIONS.

BY FRANKLIN T. JONES.
University School, Cleveland, Ohio.

Readers of SCHOOL SCIENCE AND MATHEMATICS *are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Problems and Questions for Solution.

You are requested to answer the questions numbered 177, 178, 179, 180 and 181 *in the following list:*

ENTRANCE EXAMINATION IN PHYSICS, WILLIAMS COLLEGE, SEPT. 20, 1911.

The candidate is to answer eight questions, selecting two from each of the groups A, B, C and D. Whenever a numerical result is given the *process of calculation* should be indicated.

A.

1. Simultaneous readings of two mercurial barometers, one at the base, the other at the top of a building 3400 centimeters high, gave results differing by 3 millimeters (due to difference of altitude alone). If the density of mercury is 13.6, what is the average density of the air between the two stations?

177. In a wheelbarrow the point of application of the hand on the handlebar is 4.5 feet from the axle of the wheel. The wheelbarrow weighs 30 pounds, its center of gravity being in the plane of the handlebars 1.5 feet from the axle. How great is the vertical force exerted by each hand? With what force does the wheel press on the ground?

178. The 600-pound hammer of a pile driver is raised 20 feet and is then allowed to fall on the head of a pile, which is thereby driven 2 inches into the mud. Find the average force exerted by the hammer on the head of the pile.

B.

4. Experiments have been performed in which liquids, confined in thick-walled metal tubes, have been subjected to pressures as high as 7000 atmospheres. Under these pressures the containing tubes are likely to break open. Explain why such experiments would be much more dangerous if a gas, like air, were used—rather than a liquid. (*Suggestion:* Consider the energy of the compressed gas or liquid.)

179. If the density of air, under ordinary conditions, is .0013 gm. per cu. cm., what would be its density under a pressure of 7000 atmospheres, assuming no change in temperature, and assuming strict conformity to the laws which hold good for moderate pressures?

180. A newspaper is held 2 feet distant from an 8 candle power incandescent lamp. At what distance from a 40 candle power mantle burner would the paper receive the same illumination (as from the incandescent lamp at a distance of 2 feet)?

6. Explain the difference between real images and virtual images. With a converging lens of 1-foot focal length, where (that is, at what distance from the lens) should one place an object in order to obtain (1) a real and diminished image; (2) where should one place the object in order to obtain a real and magnified image; (3) where should one place the object in order to obtain a virtual and magnified image?

C.

7. What determines the loudness of a sound? In what way does temperature affect the transmission of sound? When sound travels with a velocity of 33000 centimeters per second, how many vibrations per second will a sound have whose wave-length is 1.5 meters?

8. Explain the following, in terms of the kinetic (molecular) theory of gases:—*gas pressure, cooling of a gas by expansion and heating by compression, Boyle's law, saturated vapor.* On what does the pressure of a saturated vapor depend?

181. How many grams of steam at 100° Centigrade must be condensed in 400 grams of water in order that the water may be warmed from 35° Centigrade to 45° Centigrade?

D.

10. Describe the Leyden jar or any other form of electrical condenser, and explain its action.

11. The potential difference between the two wires which supply electric current to a house is 110 volts. When the lamps are lighted an ammeter connected in one of the wires, where it enters the building, shows that a current of 12 amperes is flowing. What is the resistance of the circuit in the building under these conditions?

12. Explain the principle of the transformer frequently used on electric lighting circuits. Why is it more economical to transmit alternating current at high voltage and then transform it to a lower voltage for lighting purposes than it is to supply the required voltage directly?

Entrance Examination in Zo-ology, Columbia University, Sept., 1914.

Note.—Time: Two hours. The certified note-book on the laboratory work must be submitted at the examination.

1. State the essential facts regarding respiration in animals, and describe the respiratory mechanism in insect, clam and frog.
2. Describe the life-history of three insects. Discuss the economic importance of insects briefly.
3. Enumerate, as fully as possible, the structural features common to all vertebrates. Name the classes of vertebrates, state their characteristics, and cite three examples of each.
4. Cite four or five examples of marked adaptation to environment in animals. How are such adaptations produced according to the theory of natural selection? What other theories to account for organic evolution have been advanced?
5. Why do animals require protein in their food? State the most important facts regarding the digestion of protein, starch and fat.
6. Define the following: Alterations of generations, viviparous, acquired characters, asexual reproduction, hibernation, marsupial protozoan.
7. Give the general classification of the following: Star-fish, sea-anemone, porpoise, eel, opossum, centipede, cuttlefish, snail, bat, seal, coral, paramecium.

Entrance Examination in Physiography, Columbia University, September, 1914.

Note.—Time: Two hours. Candidates are required to present their certified note-books on the forty exercises as a part of the examination and also to answer the following questions as concisely as is consistent with clearness and definiteness. Use diagrams as freely as desired.

1. When does the sun rise in the east? Where does it rise on December 21st? Explain why it does not always rise at the same point in the heavens.
2. Explain why the monsoons *reverse* their direction semi-annually.
3. The average January temperature at Milwaukee, Wisconsin, is 21.3°, and at Grand Haven, Michigan, across Lake Michigan, 24.5°. Explain the difference.
4. Describe the surface features of an alluvial plain, a water-gap, a lake plain and a moraine. Mention an illustration of each.
5. What are the principal uses of lakes? Mention a region in which lakes abound and explain the reason.
6. What industries are associated with mountains, and why?
7. What features of the Atlantic Costal Plain favor commerce? What features are a disadvantage from the commercial standpoint?
8. What phenomena of the ocean are due to winds? Explain the relation in each case.

SOLUTIONS AND ANSWERS.

157. *Proposed and solved by S. W. Hockett, Ann Arbor, Mich.*

Given—A cc. of gas in eudiometer tube (r. cm. radius). Required reading—x cc.—necessary to furnish an additional volume of gas of Q times the mass of original gas, barometer reading being B. cm.

Temperatures assumed constant throughout.

Let d_1 represent normal density of first gas.

Let d_2 represent normal density of added gas.

Let h_1 and h_2 represent readings in cm. of height of mercury column above lower surface of mercury in A's and x's (final) readings, respectively.

Let $x =$ final reading in cc. of mixed gases.

Let v_1, v_2, v_3 represent respectively corrected volumes (under normal pressure) of original gas, added gas and mixture.

Let L represent position on eudiometer of lower surface of mercury, reading being in cc. Since variations in position of L can be determined only by knowing relative areas of eudiometer and lower receptacle, and latter is not taken into account, we assume that lower surface of Hg is at constant point,—L.

Then: $$v_2 = \frac{v_1 Q d_1}{d_2}; \qquad 760 v_1 = A(B-h_1);$$

$$x(B-h_2) = 760 v_3 = 760(v_1+v_2);$$

i. e., $$x(B-h_2) = 760\left(v_1+\frac{v_1 Q d_1}{d_2}\right) = 760 v_1\left(1+\frac{Qd_1}{d_2}\right) = A(B-h_1)\left(1+\frac{Qd_1}{d_2}\right).$$

(1) or $$x = \frac{A(B-h_1)\left(1+\frac{Qd_1}{d_2}\right)}{(B-h_2)} = (x = L-h_2\pi r_2)$$

(2) $$h_1 = \frac{L-A}{\pi r^2}; \qquad h_2 = \frac{L-x}{\pi r^2}. \qquad x = L-h_2\pi r^2$$

(3) or $$x = \frac{kA\left(B-\frac{(L-A)}{\pi r^2}\right)}{\left(B-\frac{L-x}{\pi r^2}\right)},$$ k in this case being 3.

Here we have two equations involving two variables, x, h_2, all other quantities being observable or calculable data at beginning of experiment. These are resolved into one quadratic.

In problem given above, $Q = 2$, densities of gases are same (both being same gas), so our equation for final mixture becomes:

$$x = \frac{A(B-h_1)\ (3)}{(B-h_2)} = \frac{3A(B-h_1)}{(B-h_2)}\left(\text{or } \frac{kA(B-h_1)}{(B-h_2)}\right) \quad k\left\{\begin{array}{l}\text{being const.}\\ k = \left(\frac{Qd_1}{d_2}+1\right)\end{array}\right.$$

So $x = \frac{3A(B-h_1)}{(B-h_2)}$ and $h_2 = \frac{L-x}{r^2}$ are the two equations desired.

If, e. g., our eudiometer be one of such capacity that L may be kept at 50cc.,

$$x = \frac{3A\left(B-\frac{50-A}{\pi r^2}\right)}{\left(B-\frac{50-x}{\pi r^2}\right)}; \text{ from which } x = \pm\sqrt{kA(\pi B r^2-L+A)+\left(\frac{\pi r^2-h}{2}\right)^2} - \frac{\pi r^2-L}{2}$$

(inserting 3 for k, and 50 for L.)

Note.—In this final general equation, it will be noted that (r) occurs only as πr^2, which is the area of the eudiometer's cross section. This value

$\pi r^2 \left(\text{or} \frac{\pi}{4} d^2\right)$ may therefore be solved once for all for *each* eudiometer in a moment's time with the inside calipers (assuming it to be a uniform cylinder). The value L may be chosen according to the capacity of eudiometer, and the substitution made as follows, O being (πr^2) area of tube.

$x = \sqrt{k\text{A}(\text{BO}-\text{L}+\text{A}) + \left(\frac{\text{O}-h}{2}\right)^2} - \frac{\text{O}-\text{L}}{2}$ in which equation, $k = \left(\frac{\text{Q}d_1}{d_2} + 1\right)$ as before.

This equation may be used in synthesis of water experiment, etc., or in testing electrolytically the effect of oxygen upon other gases, as e. g. Helium (3.99), without the necessity of having the *deep* basin full of mercury, to adjust volumes to room pressure each time, the only thing needing readjustment being the position of lower surface to some fixed point on the eudiometer.

158. *Proposed by E. V. Hjort, Mason City, Iowa.*

Why can glass be cut under water with a pair of shears?

Mr. B. H. Collier of The Cleveland Window Glass Co. reports that their men have tried the method but were unsuccessful.

Mr. Hjort reports that the question was brought up by the son of a man who used the method successfully in his business.

Has anyone else had experience, successful or otherwise?

160. *Proposed by H. C. McMillan, Kingman, Kan.*

Compare the times of descent of a hollow and a solid sphere rolling down an inclined plane.

[*Note by the Editor.*—A number of objections have been raised to the answer to this problem published in the January issue.]

A correction by D. L. Rich, Ann Arbor, Mich.

A hollow sphere and a solid sphere, under the influence of gravity alone, will *not* roll down an inclined plane with the same accelerations. Although the acceleration of any body thus rolling down an inclined plane is independent of the mass of the body, it is not independent of the distribution of that mass; i. e., the acceleration is not independent of the moment of inertia of the body.

The moment of inertia of a hollow sphere, about any diameter of the sphere, is

$$\text{I}_0 = \tfrac{2}{5}\text{M}\left[\frac{r_2^4 + r_2^3 r_1 + r_2^2 r_1^2 + r_2 r_1^3 + r_1^4}{r_2^2 + r_2 r_1 + r_1^2}\right],$$

where M is the mass and r_1 and r_2 the inner and the outer radii respectively. (In the limiting cases, if $r_1 = 0, \text{I}_0 = \tfrac{2}{5}\text{M}r_2^2$, the moment of inertia of a solid sphere; and if $r_1 = r_2, \text{I}_0 = \tfrac{2}{3}\text{M}r_2^2$, the moment of inertia of a thin spherical shell.)

If a hollow sphere be placed on a plane whose angle of inclination is θ, the torque due to the weight of the sphere is $\text{M}gr_2 \sin\theta$; and this torque produces an angular acceleration α such that

$$\text{M}gr_2 \sin = \alpha \text{I}.$$

where I is the moment of inertia of the sphere about the instantaneous axis of rotation, viz., a tangent to the sphere through the point of contact between sphere and plane. $(\text{I} = \text{I}_0 + \text{M}r_2^2)$

Inserting the value of I, and solving this equation for αr_2, ($\alpha r_2 = a$, the linear acceleration), gives

$$a = g \sin\theta\left[\frac{5r_2^2(r_2^2 + r_2 r_1 + r_1^2)}{5r_2^2(r_2^2 + r_2 r_1 + r_1^2) + 2(r_2^4 + r_2^3 r_1 + r_2^2 r_1^2 + r_2 r_1^3 + r_1^4)}\right].$$

Here again in the limiting cases, if $r_1 = 0, a = \tfrac{5}{7} g \sin\theta$, the linear accelera-

tion of a solid sphere; and if $r_1 = r_2, a = \frac{3}{5} g \sin\theta$, the linear acceleration of a thin spherical shell.

Since the accelerations are different, the times in rolling any given distance will also be different, the time varying inversely as the square root of the acceleration.

Extract from a solution by Eugene M. Berry, Hamilton, N. Y.

If two objects could be made to slide without friction there would be no difference in the times of descent, whether hollow or solid, etc.

But when a sphere rolls some force is required to cause the sphere to rotate. Hence a sphere will roll slower than it would slide without friction.

Now if we have two spheres of same size and weight, but one hollow, the other solid, more force would be required to rotate the hollow sphere than the solid sphere. For the mass would average to be further from the center in the hollow sphere than in the case of the solid sphere. From the principle of moments or principle of the lever we know that the further away a certain mass is from the center of rotation the greater will be the force required to cause it to revolve about the center.

Also solved by Niel Beardsley, Bloomington, Ill.; H. C. McMillan, Kingman, Kan.; Willis K. Weaver, St. Louis, Mo.; Olaf Rognley, Northfield, Minn.

NEW BUILDINGS AT THE UNIVERSITY OF CHICAGO.

The new Howard Taylor Ricketts Laboratory, located on Ellis Avenue near the Psychological Laboratory, is now fully equipped for research work by the Departments of Pathology and of Hygiene and Bacteriology. The laboratory, which has been built at a cost of $50,000, meets an urgent need of the departments concerned.

The Classics Building, fronting on the Midway, will be one of the most artistic buildings on the quadrangles. The stone work is now completed, and the tile roof is practically done. The building, which is now practically finished will cost over a quarter of a million dollars. The designers are Shepley, Rutan & Coolidge, of Boston, who were also the architects of the William Rainey Harper Memorial Library in the same block of buildings.

ENORMOUS RAINFALL IN HAWAII.

The rainfall on the island of Hawaii varies greatly, ranging from the enormous downpour of 353 inches a year in the upper Waipio Valley to 20 inches on some of the slopes of Hualalai. The only surface streams on the island are found along the northeast coast between Hilo and Kohala. Waipio River, according to the United States Geological Survey, is the largest stream on the island and has been partly developed for irrigation. At Kapoho, on the east point of the island, warm water flows from seams in the rocks. These "warm springs" flow into a pool about 100 feet long, 25 feet wide, and 20 feet deep. The pool is entirely surrounded by rocks and its color varies in shade from a beautiful blue to violet. Waiapele, or Green Lake, is a body of fresh water in the pit of an old crater near Kapoho. This lake covers an area of about 5 acres and is fed by springs below the surface. A pumping plant takes water from this lake for domestic use and for irrigations.

LIVE CHEMISTRY.

By H. R. Smith, *Lake View High School, Chicago.*

We wish to ask teachers of Chemistry if the main thought and emphasis in planning a year's work for a class is not generally given to the choice of a textbook? The second consideration is given to choosing a manual of experiments to *illustrate* the *text*. This is the order and plan of most of the text writers when they prepare a book for teachers' use. The ability and training of the teacher, as a factor in instruction, takes third place in the above plan; because the majority of teachers are content to submerge their own individuality and assign a lesson to students because it is the next one in the text rather than attempt some original thinking in the effort to have a lesson that will have some practical bearing on the everyday activities of the student. Is it any wonder that our subject, as it is generally taught, lacks vital interest for our students?

Two bulletins of the University of Texas, No. 329 and No. 375, in two parts, have recently come to our notice. It is with great interest that we notice that the author, Dr. E. P. Schoch, has reversed the order of importance of the three factors of teaching as mentioned above. We believe his "general requirements" for a valuable course in Chemistry are excellent and commend them to other teachers.

I. A properly prepared teacher.

II. A proper class time allowance. The time spent in the class must not be less than three recitation periods of forty-five minutes and two laboratory periods of ninety minutes a week for one year.

III. A fairly well equipped laboratory in which the students do individual work.

IV. Some evidence that the teacher occupies the time with a well-planned and well-conducted course. This evidence is obtained by a personal visit of an official and an inspection of the note books and examination papers of the students in the course. The examination questions and the note books have been found to be very good indicators of the preparation of the teacher, and of the time and thought he spends in planning the course, selecting suitable topics and conducting the course; for affiliation credit it is not only the student's work that is to be judged, but first of all the teacher's work and his ability. Little or no attention is paid to the text books used because a well-prepared teacher can give a good course even with a poor text, and a poorly prepared teacher may not succeed even with an excellent text. A mere following of the text will always produce a course of relatively low value, while for the future development of the state first-class high school chemistry courses are absolutely necessary.

First and most important is the teacher. The University of Texas accepts for affiliation credit any courses which meet these requirements. Such liberal requirements must surely keep the university free from the charge of dominating the high schools.

"Since only a small percentage of students who take courses in general chemistry pursue the subject farther in college, these general courses should be designed primarily for the students who will *not continue* the study of chemistry beyond such a course. Fortunately, courses may be designed so as to suit both this class of students and also the class of students who intend to continue the subject as a specialty. It is intended here to show how this may be done.

Every school course must fulfill three requirements. First, it must give mental training; second, it must present the subject systematically—that is, it must facilitate the further study of the subject; third, it must interest the student in the subject, which is done usually by showing him what use he

may make of what he has learned. The topics for a course in chemistry must be selected so as to meet all three of these requirements: To attempt to attain only one of these will produce a course of much less value. By selecting topics from the domains of pure and of applied chemistry, a course may be obtained which fulfills all three of these requirements. It should be emphasized that both pure and applied chemistry are necessary to attain the object sought."

We suggest that teachers of chemistry request a copy of these bulletins of Dr. E. P. Schoch of Austin, Texas, and study his "LIST OF TOPICS FOR A GENERAL COURSE IN CHEMISTRY AND REASONS FOR SELECTING THEM." He has selected as his topics many that deal directly with the industries, vocations and activities of the people of his own state. Aside from many standard experiments, he studies hydrocarbons with the distillation of crude petroleum and the refining of its products. The use of tar oils as germicides and for preserving timber. The study of fats and oils is clustered chiefly around cotton seed oil: Herty's method of determining the per cent of oil in the seed, the use of cotton seed oil in food products and in soap making. The following experiment, used to distinguish linseed oil from other oils, is given in full as one of general interest in all states:

METHODS USED IN DISTINGUISHING BETWEEN LINSEED AND SIMILAR OILS.

Linseed oil in paints is frequently adulterated with or replaced by corn oil, cotton oil, fish oil and rosin oil. The following are some of the most important means used by chemists to distinguish between these oils or to ascertain if they are essentially pure. These methods are mainly quantitative: qualitative tests are of little value because they do not reveal the extent of the adulteration, and slight amounts of adulterations are frequently negligible.

230. The constants to be used here to distinguish between these oils are the following:

Name of Oil.	Specific Gravity. at 15° C.	Maumené Number.
Raw linseed oil	.931-.937	103-126°C.
Boiled linseed oil	.936-.938	100-
Fish oil	.927-.933	123-128°
Cotton seed oil	.921-.930	70- 90°
Corn oil	.921-.927	70- 90°
Rosin oil	.987-1.0	32-

231. Since these constants are nearly the same for fish oil as for linseed oil, and since fish oil is a very undesirable oil in paint and should be entirely absent, the following qualitative test is added here in order to aid in its detection: Heat a little of the oil nearly to 100° C. and rub a drop of it on the back of the hand. A fishy odor reveals the presence of fish oil.

232. Rosin oil is another very undesirable, but frequently used, adulterant of linseed oil; surfaces painted with it become "tacky" or "alligator," as it is called, and under the influence of light and air the oil is soon completely destroyed.

The quantitative constants given above serve to reveal any extensive adulteration of linseed oil by means of rosin oil, but, since it is not always convenient to make such a test, the following qualitative test is here added for practical purposes: Warm a little of the oil and add an equal volume of glacial acetic acid. Mix thoroughly, and cool the mixture with tap water; then add one drop of concentrated sulfuric acid; pure linseed oil gives a sea green color, but when adulterated with rosin oil a violet color shows itself temporarily.

233. Secure a sample of three oils—e. g., of raw linseed oil, of cotton

seed oil and of rosin oil. If desirable, the oil from some mixed paint may also be examined. For this purpose allow the paint to settle in a narrow, tall vessel and drain or siphon off some of the supernatant clear oil. If the paint will not settle readily, dilute some of the oil with carbon tetrachlorid, and after separating the clear liquid from the solid, remove the carbon tetrachlorid by distillation (save it).

Take the specific gravity of these oil samples, and determine their Maumené numbers. By means of this data, decide whether or not the oils are pure.

Why Chemistry Should Be Taught in High Schools.

Today our home life, our commerce and the practice of our trades and professions involve chemical operations so frequently and require so much knowledge of the composition and properties of substances that the acquisition of such knowledge by young people is really a prime necessity. A course in chemistry can give such information. Of course, *training* is the first object of all school work, but in the study of chemistry training can be given while information of practical value is given. General facts and principles can be illustrated with materials met in daily life as well as, if not better than, with substances rarely met with. A course in chemistry can include more information of practical value than probably any other high school course, and if properly conducted the chemistry course will serve to train young minds just as well as any course primarily designed for this purpose. The study of chemistry gives young people much that is essential in all walks of life, and it is an absolute necessity for the great number who deal directly with materials, such as painters, builders, merchants, farmers, housekeepers and many others.

TWO DEVICES TO ADD INTEREST TO REVIEW WORK IN ELEMENTARY CHEMISTRY.

By Agnus Bandel.

Towson High School, Towson, Maryland.

Though chemistry should not be taught simply as a memory study, still the facts once learned must be remembered in order to be used in subsequent lessons. No one learns a thing once for all, and most teachers will agree that occasional drill and frequent reviews are very necessary in elementary chemistry. How to conduct such work so as not to bore the best students and to compel the attention of those below the average is quite an important problem. Two devices which have been of some assistance in my own work may help others.

One is an adaptation of the old game of question and answer. The instructor tells the class he has in mind some substance that they have used in the laboratory, and they begin to ask questions to discover its identity. She answers only questions that can be answered by "Yes" or "No"—that is, "Has it color?" "Is it a gas?"—but refuses to answer any such as "Is it carbon dioxide?" The latter question should have been, "Is limewater a test for it?" The student naming the substance correctly may then be allowed to choose the next one to be guessed by the class. This method, by its appeal to puzzle-loving instinct of boys and girls of high school age, interests them individually, and brings to the attention of the class many characteristic properties of substances that would otherwise be forgotten almost as soon as the experiments with them are finished.

The other scheme involves more work on the part of the instructor, but

has also proved serviceable in review work. A set of questions is made out, each on a separate card, and these are given around the class, the same number to each student. The cards, question side downward, are laid on the desk until the student's turn arrives. He then reads aloud the question on the top card and answers it if he can. If his reply is correct, he keeps the card, and the next takes his turn. If, however, the answer is not right, the student calls upon some member of the class. If the one called upon gives the correct reply, he receives the card. If the student called upon fails to give the correct response, volunteers may be called for. If the right answer is not obtained from some member of the class, the interrogator retains the card. The student holding the greatest number of cards at the end of the period is the winner. Should each of two pupils answer only part of a question, the card can be forfeited to the instructor, or each can be given a card. The success of the game depends upon the speed with which it is played and upon the kind of question. The latter must be such as require definite short answers. On acids, bases and salts, questions like the following are suitable: "What is muriatic acid?" "What is the formula for sulphuric acid?" "What are chlorides?" "Name two chlorides." By means of this device one can review rapidly from sixty to eighty questions in a single period. It not only holds the interest of every pupil during the entire period, but also helps him to find out what he really knows.

A good set of general questions could also be used from time to time. Questions such as, "What are the two liquid elements?" "Name two gases that are acids." "Name two solids that are acids."

WHAT NEW YORK IS DOING FOR VISUAL INSTRUCTION.

One of the most interesting of instructive methods that has recently come into vogue is that of visual instruction, both by the older type of stereopticon slide and later by the motion picture view. This is something in which the pupil is always interested, and when his interest can be secured, he is being instructed.

The New York educational department is making a special feature in lending to schools, and to other educational institutions of the state, lantern slides and matter of that nature, with the distinct understanding that these will be used for strictly free instruction if no charge is made for their use. This plan is meeting with universal success, and it would be well for other cities to institute schemes of this sort.

This is on the order of the N. W. Harris Foundation of the Columbian Field Museum of Chicago, in which matter belonging to the Museum is lent to the various schools of the city, being delivered and called for by the Museum authorities, the expense being borne by the Foundation.

Superintendent L. E. Amidon of Iron Mountain, Michigan, has just tendered his resignation to the Board of Education of that town, the resignation to take effect at the close of the present school year.

He has administered the schools in this place for nearly twenty years. During his management a splendid new High School building has been erected. He has also instituted a scheme in Iron Mountain which permits his pupils to attend school for half a day, while the rest of the day is devoted to some occupation by means of which the pupil can earn money.

Mr. Amidon will take charge of the Rivers Teachers' Agency in the Auditorium Building, Chicago, after the middle of June.

MILWAUKEE BIOLOGY TEACHERS.

On Oct. 14, 1914, the biology teachers of Milwaukee had a meeting and organized themselves into a society for mutual help, to be known as the Milwaukee Biology Club. The membership of the organization will include representatives from all of the Milwaukee High Schools, the Milwaukee-Downer College, Milwaukee University, Milwaukee Normal School, and the Milwaukee Public Museum.

The subject of Heredity has been chosen for the year's study. Meetings will be held once a month in the Public Museum.

It is expected that this new club will do much in creating new interest and more enthusiasm in the subject of Biology in the city of Milwaukee,

Fred W. Werner is president, Leon D. Peaslee, vice-president, and Lucie Harmon, secretary.

REPORT OF THE 69TH MEETING OF THE EASTERN ASSOCIATION OF PHYSICS TEACHERS.

This meeting was held at the Newton Technical High School, Newtonville, Mass., Saturday, Dec. 12, 1914.

The meeting was called to order by President Timbie at 9:45, and Mr. Boyleston was called on for a report of the Committee on New Books. Mr. Peterson read a review of the new Physics Text by Mr. A. M. Butler. This was followed by a report by Mr. Boyleston of a review of "The Elements of General Science," by Caldwell & Eikenberry of the University of Chicago, and also by a report on "Physics of the Household," by Carleton J. Lynde, of MacDonald College, Canada, and "A Handbook of Chemistry and Physics," recently published by the Chemical Rubber Co., of Cleveland, Ohio.

The meeting was disappointed in not being able to hear a report from the Committee on Magazine Literature. This, however, will probably appear on the next program.

Mr. Emerson Rice, chairman of the Committee on Current Events in Physics, reported in a very interesting way the work of the committee. He mentioned a great number of recent occurrences that have taken place in the Physics world.

Mr. Harrington of the Newton Technical High School then demonstrated a new form of rotary converter which has recently been put on the market by the Holtzer Cabot Co. This is an interesting piece of apparatus, and people who are considering the installation of something of this variety, should communicate with this company before purchasing.

Mr. Hall showed a modification of the Knott cups, designed for the purpose of showing the rate of radiation from rough and smooth surfaces.

Several additions were made to the membership of the Association.

Following this, Mr. C. S. Griswold, of the Groton School, gave a most interesting address on "A Sabbatical Year's Experience in the Industries." This address made all who heard it wish that their Boards of Education would grant a Sabbatical year with full pay, in order that they might better equip themselves by travel and study for future work.

This address was followed by one by Prof. Homer W. LeSouard, on "Efficiency and Equipment of the Physics Teacher." The subject was handled in a masterly way, as the speaker is abundantly able to speak from this point of view.

The meeting taken from all points of view, was one of the most interesting that the Association has held in a long time. C. H. S.

PROBLEM DEPARTMENT.

By I. L. Winckler,
Central High School, Cleveland, Ohio.

Readers of this magazine are invited to propose problems and send solutions of problems in which they are interested. Problems and solutions will be credited to their authors. Address all communications to I. L. Winckler, 32 Wymore Ave., E. Cleveland, Ohio.

Algebra.

416. *Proposed by D. H. Richert, Newton, Kansas.*

Solve: $x^3+x^2-x/3+1=0.$

I. *Solution by Walter C. Eells, Annapolis, Md.*

To reduce to the standard form $y^3+py+q=0$, substitute $x=y-\frac{1}{3}$ and get $y^3-\frac{2}{3}y+\frac{32}{27}=0$. Since the discriminant of this cubic,

$$\frac{q^2}{4}+\frac{p^3}{27}=\frac{2}{27}\sqrt{62}$$

is greater than 0, the equation has one real and two imaginary roots.

By Cardan's formula they are

$$y_1=\frac{1}{3}(-16+2\sqrt{62})^{\frac{1}{3}}+\frac{1}{3}(-16-2\sqrt{62})^{\frac{1}{3}}$$

$$y_2=\frac{\omega}{3}(-16+2\sqrt{62})^{\frac{1}{3}}+\frac{\omega^2}{3}(-16-2\sqrt{62})^{\frac{1}{3}}$$

$$y_3=\frac{\omega^2}{3}(-16+2\sqrt{62})^{\frac{1}{3}}+\frac{\omega}{3}(-16-2\sqrt{62})^{\frac{1}{3}}$$

Where ω and ω^2 are the complex cube roots of unity.

From these results

$$x_1=y_1-\tfrac{1}{3},\quad x_2=y_2-\tfrac{1}{3},\quad x_3=y_3-\tfrac{1}{3}.$$

An approximate value of the real root x_1 is -1.5993.

II. *Solution by William W. Johnson, Cleveland, Ohio.*

Multiplying the roots by m. Put $x=\dfrac{y}{m}$

$$y^3+my^2-\frac{m^2y}{3}+m^3=0.$$

By inspection, 3 is the least value of m which will make all the coefficients integral.

Substituting 3 for m, $\quad y^3+3y^2-3y+27=0.$ (2)

Transform into an equation whose second term is zero. Put $y=z-1$.

Diminishing the roots of (2) by -1, we get $z^3-6z+32=0.$ (3)

This is of the form $\quad z^3+pz+q=0.$ (A)

In which $\quad p=-6$, and $q=32$.

When p is negative and $-4p^3<27q^2$, equation (A) has one real and two imaginary roots which are found by the formulas:

$$\sin\psi=-\frac{2}{q}\sqrt{-\frac{p^3}{27}} \qquad \text{(B)}$$

$$\tan\tfrac{1}{2}\Phi=\sqrt[3]{\tan\tfrac{1}{2}\psi}. \qquad \text{(C)}$$

$$z_1=\frac{2}{\sin\Phi}\sqrt{-\frac{p}{3}} \qquad \text{(D)}$$

$$z_2\ \&\ z_3=-\frac{z_1}{2}\mp\frac{z_1\sqrt{3}}{2}\cdot\cos\Phi\,\sqrt{-1}. \qquad \text{(E)}$$

By (B) $\sin\psi = -\frac{1}{8}\sqrt{2}.$

$\psi = -(10^\circ\ 10'\ 55.44'').$

$\frac{1}{2}\psi = -(5^\circ\ 5'\ 27.72'').$

By (C) $\frac{1}{2}\Phi = -(24^\circ\ 4'\ 00.194'').$

$\Phi = -(48^\circ\ 8'\ 00.388'').$

By (D) $$z_1 = \frac{2\sqrt{2}}{\sin\Phi}$$

$z_1 = -3.798070.$

By (E) $z_2\ \&\ z_3 = +1.899035 \pm 1.827925\sqrt{-1}.$

From (2) $y = z - 1$, whence

$y_1 = -4.798070;\ y_2\ \&\ y_3 = +0.899035 \pm 1.827925\sqrt{-1}.$

$x = \frac{y}{3}$; then the roots of the given equation are:

$x_1 = -1.599357;\ x_2\ \&\ x_3 = +0.299678 \pm 0.609308\sqrt{-1}.$

Geometry.

417. *Proposed by Henry B. Sanders, New York, N. Y.*

If a circle be circumscribed about a triangle, the points in which tangents at the vertices meet the opposite sides lie on the same straight line.

I. *Solution by James H. Weaver, West Chester, Pa.*

Let ABC denote the triangle; BE, CF and AD the tangents meeting the opposite sides in E, F and D, respectively.

To show that E, F, D, are collinear.

They will be collinear if $\frac{BF \cdot CD \cdot AE}{AF \cdot BD \cdot CE} = 1.$

By similar triangles we have

$$\frac{AB}{BC} = \frac{AE}{BE} = \frac{BE}{CE}$$

$$\frac{AC}{AB} = \frac{CD}{AD} = \frac{AD}{BD}$$

$$\frac{BC}{AC} = \frac{BF}{CF} = \frac{CF}{AF}$$

By multiplication

$$1 = \frac{AE \cdot CD \cdot BF}{BE \cdot AD \cdot CF}$$

$$\text{and } 1 = \frac{BE \cdot AD \cdot CF}{CE \cdot BD \cdot AF}$$

$$\therefore 1 = \frac{AE \cdot CD \cdot BF}{CE \cdot BD \cdot AF}$$

II. *Solution by Norman Anning, Clayburn, B. C.*

Let ABC be the given triangle and let the lines QAR, RBP, PCQ be tangents to the circle at A, B, C respectively.

Since $$\frac{PB}{PC} = \frac{QC}{QA} = \frac{RA}{RB} = 1.$$

$\frac{PB \cdot QC \cdot RA}{RB \cdot PC \cdot QA} = 1$ and the lines AP, BQ, CR are concurrent (Ceva).

Hence the poles of these lines with respect to the circle ABC will be collinear.

The pole of AP must lie on the polars of the points A and P, i. e., at the point where the tangent at A cuts BC. Similarly for the poles of BQ and CR. The theorem follows.

III. *Solution by Nelson L. Roray, Metuchen, New Jersey.*

Let the tangents at C, B, A cut BA, AC, BC, at the points Z, Y, X, respectively.

Then if $\frac{\sin BAX}{\sin CAX}\cdot\frac{\sin CBY}{\sin ABY}\cdot\frac{\sin ACZ}{\sin BCZ}=1$, X, Y and Z are collinear.

$\angle BAX=\angle A+\angle B,\ \angle CBY=180^\circ-A,\ \angle ABX=\angle C,$

$\angle ACZ=\angle CAX,\ \angle BCZ=\angle C+\angle B.$

$$\therefore\ \frac{\sin BAX}{\sin CAX}\cdot\frac{\sin CBY}{\sin ABY}\cdot\frac{\sin ACZ}{\sin BCZ}=\frac{\sin(A+B)}{\sin CAX}\cdot\frac{\sin A}{\sin(B+A)}\cdot\frac{\sin CAX}{\sin(B+C)}$$

$=1.$ $\therefore$ X, Y and Z are collinear.

IV. *Solution by E. L. Brown, Denver, Colorado.*

Let ABC be the given triangle. Let the tangents at A, B, C meet the opposite sides at Q, P, R, respectively. Let AQ cut CR and BP at B′ and C′, respectively, and let BP cut CR at A′.

Then AA′, BB′, CC′ are concurrent. (See solution of Problem 93, SCHOOL SCIENCE AND MATHEMATICS, April, 1908.)

A′B′, the third diagonal of the complete quadrilateral AKBC′, is divided harmonically at C and R. Also B′C′, the third diagonal of the complete quadrilateral A′CKB, is divided harmonically at A and Q.

Therefore, CA, A′C′, and RQ must be concurrent.

418. *Proposed by A. C. McMillin, Washington, Kansas.*

ABC is a right-angled triangle, B is the right angle, BL is the perpendicular to AC. On the side of BC remote from A, the square BCDE is described, and the line AD cuts BL in M.

Prove that $$\frac{1}{BM}=\frac{1}{AC}+\frac{1}{BL}.$$

I. *Solution by E. L. Brown, Denver, Colorado, and Nelson L. Roray, Metuchen, New Jersey.*

Draw DF perpendicular to AC produced.

In the equal right triangles BLC and CFD, $FD=CL$ and $FC=BL$.

In the similar right triangles ALM and AFD,

$$\begin{aligned}
&AF:AL=FD:LM.\\
\therefore\quad &AC+BL:AL=CL:ML,\\
&AC\cdot ML+BL\cdot ML=AL\cdot CL=\overline{BL}^2,\\
&AC\cdot ML=BL(BL-ML)=BL\cdot BM,\\
&AC(BL-BM)=BL\cdot BM,\\
&AC\cdot BL=BL\cdot BM+AC\cdot BM,
\end{aligned}$$

$$\frac{1}{BM}=\frac{1}{AC}+\frac{1}{BL}.$$

II. *Solution by T. M. Blakslee, Ames, Iowa.*

Take AB and BC as axes of X and Y, B being the origin.

A, B, C and D are (—C, O), (O, O), (O, A) and (A, A).

The equations of AC, AD and BL are, respectively,

$$y=\frac{a}{c}(x+c),\quad y=\frac{a}{a+c}(x+c)\ \text{ and }\ y=-\frac{c}{a}x.$$

$$\therefore\ \text{L and M are }\left(-\frac{a^2c}{a^2+c^2},\frac{ac^2}{a^2+c^2}\right)\text{ and }\left(\frac{-a^2c}{a^2+ac+c^2},\frac{ac^2}{a^2+ac+c^2}\right)$$

$$\therefore\ AC=\sqrt{a^2+c^2},\ \frac{1}{AC}=\frac{ac}{ac\sqrt{a^2+c^2}}$$

$$BL=\frac{ac}{\sqrt{a^2+c^2}},\ \frac{1}{BL}=\frac{a^2+c^2}{ac\sqrt{a^2+c^2}}.$$

$$BM = \frac{ac\sqrt{a^2+c^2}}{a^2+ac+c^2}, \frac{1}{BM} = \frac{a^2+ac+c^2}{ac\sqrt{a^2+c^2}}.$$

$$\therefore \quad \frac{1}{BM} = \frac{1}{AC} + \frac{1}{BL}.$$

III. *Solution by Norman Anning, Clayburn, B. C.*

From M draw MN perpendicular to AB. Let $BM = x$.

From similar triangles $MN = \frac{cx}{b}$, $BN = \frac{ax}{b}$, $AN = C - \frac{ax}{b}$

$$MN : AN = DE : AE = a : a+c.$$

$$\therefore \quad \frac{cx}{b}(a+c) = \left(c - \frac{ax}{b}\right)a.$$

Or

$$acx + c^2x = abc - a^2x.$$

$$\frac{1}{x} = \frac{ac+a^2+c^2}{abc} = \frac{ac}{abc} + \frac{a^2+c^2}{abc} = \frac{1}{b} + \frac{b}{ac}$$

$$\therefore \quad \frac{1}{BM} = \frac{1}{AC} + \frac{1}{BL}.$$

419. *Proposed by W. A. Tippie, Troy, Ohio.*

A cylindrical tank is 10 feet in diameter and has ends which are hemispheres of the same diameter. Its total length is 60 feet. If it is lying in a horizontal position, how many gallons of water will be required to fill it to a depth of two feet?

Solution by Gertrude L. Roper, Detroit, Mich.

Let O be the center of the base of the cylinder, and X and Y the points in which the surface of the water cuts the circumference of the base.

The volume of a spherical segment $= \frac{1}{2}\pi a(r_1^2+r_2^2) + \frac{1}{6}\pi a^3$, where $a =$ the altitude and r_1 and r_2 the radii of the bases.

If the hemi-spherical ends are placed together they will form a sphere and the water in them a spherical segment of one base.

$XY = 8$, $r_1 = 4$, $r_2 = 0$, $a = 2$.

$\therefore$ Volume of water in the two ends $= 54.454+$.

$\angle XOY = 2 \tan^{-1} \frac{4}{3} = 106°.258$.

$$\frac{25\pi}{\text{sector XOY}} = \frac{360}{106.258}. \quad \therefore \text{ Sector XOY} = 23.18 \text{ square feet.}$$

Area triangle $XOY = 12$.

$\therefore$ area segment remaining $= 23.18 - 12 = 11.18$.

$\therefore$ volume of water in cylinder $= 559$ cu. ft.

Total volume of water $= 559.0 + 54.454 = 613.454$ cu. ft. $= 4589+$ gallons.

Trigonometry.

420. *Proposed by James H. Weaver, West Chester, Pa.*

If a dodecahedron and an icosahedron are inscribed in the same sphere, the triangular face of the icosahedron and the pentagonal face of the dodecahedron may be inscribed in the same circle.

I. *Solution by E. L. Brown, Denver, Colorado, and T. M. Blakslee, Ames, Iowa.*

Let I = inclination of faces.

Let R = radius of circumscribed sphere.

Let a = one of the edges.

Let m = number of faces that form a solid angle.

Let n = number of sides of a face.

Then $\sin \frac{1}{2} I = \cos \frac{\pi}{m} \Big/ \sin \frac{\pi}{n}$ and $R = \frac{a}{2} \tan \frac{1}{2} I \tan \frac{\pi}{m}$. (1)

(See Chauvenet's *Plane and Spherical Trigonometry*, Art. 192.)
By means of (1) we easily find

$$K \equiv \text{edge of icosahedron} = \frac{R}{5}\sqrt{10(5-\sqrt{5})},$$

$$D \equiv \text{edge of dodecahedron} = \frac{R}{3}(\sqrt{15}-\sqrt{3}).$$

But $T \equiv$ side of inscribed equilateral triangle $= r\sqrt{3}$,

$$P \equiv \text{side of inscribed regular pentagon} = \frac{r}{2}\sqrt{10-2\sqrt{5}}.$$

The proposition is true if $\dfrac{K}{D} = \dfrac{T}{P}$

$$\frac{T}{P} = \frac{2\sqrt{3}}{\sqrt{10-2\sqrt{5}}} = \frac{\sqrt{6}}{\sqrt{5-\sqrt{5}}}.$$

$$\frac{K}{D} = \frac{3\sqrt{10(5-\sqrt{5})}}{5(\sqrt{15}-\sqrt{3})} = \frac{3\sqrt{10}\sqrt{5-\sqrt{5}}}{5\sqrt{3}(\sqrt{5}-1)} = \frac{\sqrt{6}\sqrt{5-\sqrt{5}}}{5-\sqrt{5}} = \frac{\sqrt{6}}{\sqrt{5-\sqrt{5}}}$$

$$\therefore \qquad \frac{K}{D} = \frac{T}{P}$$

Note.—For a geometric proof of this proposition, see T. L. Heath's *The Thirteen Books of Euclid's Elements*, Volume III, Page 514.

II. *Solution by Norman Anning, Clayburn, B. C.*

Let d and i be the edges of regular dodecahedron and icosahedron inscribed in a sphere of radius R. The faces may be inscribed in the same circle if they are at the same distance from the centre of the sphere, i. e., if the polyhedra have the same inscribed sphere.

$$R = \frac{d}{4}(1+\sqrt{5})\sqrt{3} = \frac{i}{4}\sqrt{10+2\sqrt{5}}.$$

It is required to show that the values of the in-radii are equal, i. e.

$$\frac{d}{4}\sqrt{\frac{50+22\sqrt{5}}{5}} = \frac{i}{4}\cdot\frac{3+\sqrt{5}}{\sqrt{3}}.$$

$$\frac{d}{4}\sqrt{\frac{50+22\sqrt{5}}{5}} = \frac{i}{4}\cdot\frac{\sqrt{10+2\sqrt{5}}}{(1+\sqrt{5})\sqrt{3}}\sqrt{\frac{50+22\sqrt{5}}{5}}$$

$$= \frac{i}{4\sqrt{3}}\sqrt{\frac{(10+2\sqrt{5})(50+22\sqrt{5})}{(1+\sqrt{5})^2\times 5}}$$

$$= \frac{i}{4\sqrt{3}}\sqrt{\frac{(2\sqrt{5}+2)(10\sqrt{5}+22)}{(\sqrt{5}+1)(\sqrt{5}+1)}}$$

$$= \frac{i}{4\sqrt{3}}\sqrt{2\times\frac{(10\sqrt{5}+22)(\sqrt{5}-1)}{(\sqrt{5}+1)(\sqrt{5}-1)}}$$

$$= \frac{i}{4\sqrt{3}}\sqrt{14+6\sqrt{5}}.$$

$$= \frac{i}{4\sqrt{3}}(3+\sqrt{5}).$$

III. *Solution by Nelson L. Roray, Metuchen, New Jersey.*

Let a be the edge of the icosahedron and p the radius of the circumsphere. The five faces about any vertex form a pyramid whose base is a regular pentagon.

The radius of this pentagon $= x = \dfrac{2a}{\sqrt{10-2\sqrt{5}}}$

$\therefore$The altitude of the pyramid $= h = a\sqrt{\dfrac{3-\sqrt{5}}{5-\sqrt{5}}}$

$\therefore$ The radius of the circum-sphere $= p = \dfrac{a}{2}\sqrt{\dfrac{5-\sqrt{5}}{3-\sqrt{5}}}$

$$\text{or } a = 2p\sqrt{\frac{3-\sqrt{5}}{5-\sqrt{5}}}$$

That is, the side of an equilateral triangle is $2p\sqrt{\dfrac{3-\sqrt{5}}{5-\sqrt{5}}}$ and the radius of the circum-circle of this triangle is $\dfrac{2p}{3}\sqrt{\dfrac{9-3\sqrt{5}}{5-\sqrt{5}}}$

Let b be the edge of the dodecahedron and p the radius of the circum-sphere. The three edges about any vertex form a pyramid whose face angles at the vertex are 108° and whose base is an equilateral triangle whose side is a diagonal of a regular pentagon.

By the Law of Cosines the diagonal $= x = \dfrac{b}{2}\sqrt{2\sqrt{5}+6}$

$\therefore$ The altitude of the pyramid $= h' = \dfrac{b}{6}\sqrt{18-6\sqrt{5}}.$

$\therefore$ The radius of the circum-sphere $= p = \dfrac{3b}{\sqrt{18-6\sqrt{5}}}$

$$\text{or } b = \frac{p}{3}\sqrt{18-6\sqrt{5}}.$$

That is, the side of a regular pentagon is $\dfrac{p}{3}\sqrt{18-6\sqrt{5}}$ and the radius of the circum-circle of this pentagon is $\dfrac{2p}{3}\sqrt{\dfrac{9-3\sqrt{5}}{5-\sqrt{5}}}$

$\therefore$ The face of the icosahedron and the face of the dodecahedron have the same circum-circle. Q. E. D.

The value of x can be found without the Law of Cosines hence may be considered algebraic.

CREDIT FOR SOLUTIONS.

408. Mary Ella Robinson, N. P. Pandya, M. G. Schucker. (3)
409. N. P. Pandya. (1)
410. Mary Ella Robinson. (1)
411. Mabel Burdick, Nelson L. Roray, M. G. Schucker, Elmer Schuyler, one incorrect solution. (5)
412. Niel Beardsley, Nelson Roray, one incorrect solution. (3)
413. Niel Beardsley, Mabel Burdick, Nelson Roray, M. G. Schucker, Elmer Schuyler, one incorrect solution. (6)
414. Mabel Burdick, H. C. McMillin, Nelson Roray. (3)
415. H. C. McMillin, Nelson Roray. (2)
416. Norman Anning, Niel Beardsley (2), T. M. Blakslee, E. L. Brown, Walter C. Eells, William W. Johnson, G. Alfred Kline, D. H. Richert, Nelson Roray, M. G. Schucker, James H. Weaver. (12)
417. Norman Anning (2), E. L. Brown, T. M. Blakslee, Walter C. Eells (2), L. E. A. Ling, H. C. McMillin, Nelson L. Roray, Elmer Schuyler, James H. Weaver. (11)
418. Norman Anning, Niel Beardsley, Paul C. Bickel, T. M. Blakslee, E. L. Brown, H. C. McMillin, Nelson L. Roray, Elmer Schuyler, James H. Weaver. (9)

419. Norman Anning, Niel Beardsley, T. M. Blakslee, E. L. Brown, Walter C. Eells, H. Jackson, William W. Johnson, H. C. McMillin, A. G. Montgomery, Gertrude L. Roper, Nelson L. Roray, H. N. Snodgrass, James H. Weaver. (13)

420. Norman Anning, T. M. Blakslee (2), E. L. Brown, Nelson L. Roray (2). (6)

Total number of solutions, 69.

PROBLEMS FOR SOLUTION.

Algebra.

431. *Proposed by the Editor.*

Solve:

$$x^2-(y-z)^2=a^2. \quad (1)$$
$$y^2-(z-x)^2=b^2. \quad (2)$$
$$z^2-(x-y)^2=c^2. \quad (3)$$

Geometry.

432. *Proposed by W. L. Baughman, East St. Louis, Ill.*

Given a triangle, altitude h and base b. A square is inscribed in the triangle, one of its sides lying in the base. Find the area of the square in terms of h and b.

433. *Proposed by Nelson L. Roray, Metuchen, New Jersey.*

A polygon of $2n$ sides is inscribed in a circle. There are n sides each equal to a and n sides each equal to b. Find the radius of the circle.

434. *Proposed by Daniel Kreth, Wellman, Iowa.*

From a point without a square the distances to the three nearest vertices of the square are 20, 30 and 40. Find the side of the square.

435. *Problem 434 in geometric form and generalized. Editor.*

To construct a triangle similar to a given triangle and having its three vertices on the circumferences of three given concentric circles.

ARTICLES IN CURRENT PERIODICALS.

American Forestry for February; *1410 H. Street, N. W., Washington, D. C.; $2.00 per year, 20 cents a copy:* "Destroying Mt. Mitchell" (with 11 illustrations), Raymond Pullman; "The Mt. Mitchell Trail" (with 3 illustrations), H. W. Plummer and N. Buckner; "Planting Time and Care of Trees," S. B. Detweiler; "Boy Scouts and Forests" (with 10 illustrations), K. W. Woodward; "Forests and Game Preservation" (with 5 illustrations), Ottomar H. Van Norden; "Improving White Mountain Forests" (with 7 illustrations), Wm. L. Hall; "Canadian Lumber Competition" (with 6 illustrations), H. D. Langille.

American Journal of Botany for January; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $4.00 per year, 50 cents a copy:* "Investigations on the Phylogeny of the Angiosperms. 5. Foliar Evidence as to the Ancestry and Early Climatic Environment of the Angiosperms," Edmund W. Sinnott and Irving W. Bailey; "The Growth-forms of the Flora of New York and Vicinity," Norman Taylor; "The Temperature of Leaves of Pinus in Winter," John H. Ehlers.

American Mathematical Monthly for January; *5548 Kenwood Ave., Chicago; $2.00 per year:* "The History of Zeno's Arguments on Motion," Florian Cajori; "Centers of Similitude of Circles and Certain Theorems Attributed to Monge. Were They Known to the Greeks?" R. C. Archibald; "A Cardioidograph," C. M. Hebbert; for February—"History of Zeno's Arguments on Motion," Florian Cajori; "Groups of Subtraction and Division With Respect to a Modulus," G. A. Miller.

Educational Psychology for February; *Warwick and York, Baltimore, Md.; $2.50 per year, 30 cents a copy:* "A Simplified Method of Conducting McDougall's Spot-Pattern Test," Mabel Goudge; "The Training of Judgment in the Use of the Ayres Scale for Handwriting," C. Truman Gray; "Articulation and Association," H. L. Hollingworth; "The Measurement of Efficiency in Writing," Daniel Starch.

Condor for January-February; *Hollywood, Cal.; $1.50 per year, 30 cents a copy:* "With *Rallus* in the Texas Marsh" (with 4 photos by the author), George F. Simmons; "The Nesting of the Black Swift" (with 4 photos by the author), William L. Dawson; "The Kern Redwing—*Agelaius phoeniceus aciculatus*" (with 6 drawings on one figure), Joseph Mailliard; "The status of the Arizona Spotted Owl," H. S. Swarth; "Niagara at Your Door: An Appeal to San Franciscans," William L. Dawson; "Birds Observed on Forrester Island, Alaska, During the Summer of 1913" (with 8 photos and 1 drawing by the author), Harold Heath; "Birds of the Boston Mountains, Arkansas," Austin P. Smith.

Guide to Nature, for February; *Arcadia, Sound Beach, Conn.; $1.00 per year, 10 cents a copy:* "Rattlers' Rattlers in Cut, Nature Study with the Camera," Edwin L. Jack; "Wonders of a Pool," "Science and the Boy," "The Ideal Quail Shelter."

Journal of Geography for March; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "What Should Elementary School Geography Include and in What Order Should Its Materials Be Presented," H. K. Fairbanks; "The European Winter and the War," Robert DeC. Ward; "Geographical Factors in the Agriculture of Du Page County, Ill.," Laura Hatch; "Cape Verd Islands; A Visit to San Vicinte in 1890," Mark Jefferson.

Journal of Home Economics for February; *Roland Park Branch, Baltimore, Md.; $2.00 per year, 50 cents a copy:* "Municipal Housekeeping," Mildred Chadsey; "The Present Need for Education, for Students of College Age, in the Problems of Family Life," Willystine Goodsell; "The Housekeeping Centers of New York," Mabel Hyde Kittredge; "Credit for Home Work," Hettie M. Anthony; "Ash Content of Canned Vegetables, With Special Reference to Canned Peas," Agnes Fay Morgan.

Mathematical Gazette for January; *G. Bell & Sons, Portugal Street, Kingsway, London; six nos. 9 s. per year, 2 s. 6 d. a copy:* "Reports of Committees," "Pythagoras," W. W. Rouse Ball; "The Achievements of Great Britain in the Realm of Mathematics" (*Concluded*), Prof. Gino Loria; "My Lecture Notes on Calculus," Prof. G. H. Bryan.

Nature-Study Review for February; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "Children's Home Gardens, Alice J. Patterson; "Vegetable Gardening for City Children," Ethel Gowans; "School and Home Gardening in Portland," M. G. Evans; "Beautifying Work in Nature-Study," Margaret Dolan; "Nature-Study in the Gary (Ind.) Schools," Margaret Ahearne; "The School Fair an Aid to Gardening," L. A. DeWolfe; "Plants for Class Rooms," Ellen E. Shaw.

Photo-Era for March; *383 Boylston Street, Boston; $1.50 per year, 15 cents a copy:* "The Work of William E. Macnaughtan," Paul L. Anderson; "Lantern-Slides in Natural Colors" Part II, William H. Spiller; "Wanted—A Uniform System of Plate-Testing," E. J. Wall; "The Goods and the Market," Frank M. Steadman; "Softening the Definition When Making Enlargements"; "An Acid Toning-Process for Developing-out Papers," George S. Hoell; "A Reflecting-Hood for the View-Camera," H. E. Balfour.

Popular Astronomy for March; *Northfield, Minn.; $3.50 per year, 35 cents a copy:* "Drawings of Mount Pico" Plate VIII, Frontispiece; "Meteorology of the Moon," William H. Pickering; "Modern Ideas on Cosmogony" (with Plate IX), Frederick C. Leonard; "The Planetary Nebulæ," Russell Sullivan; "Astronomical Teaching in the City," Mary E. Byrd.

Popular Science Monthly for March; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "Astronomy on the Pacific Coast," Russell T. Crawford; "The Biological Laboratories of the Pacific Coast," William E. Ritter; "The Last Wild Tribe of California," T. T. Waterman; "Extinct Faunas

of the Mohave Desert, Their Significance in a Study of the Origin and Evolution of Life in America," John C. Merriam; "Insects of the Pacific," Vernon L. Kellogg; "The Physiological Aspects of California for the Botanist," George J. Peirce; "The Volcanic Activity of Lassen Peak, California," Ruliff S. Holway.

Physical Review for January; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "On the Maintenance of Combinational Vibrations by Two Simple Harmonic Forces," C. V. Raman; "Resistance of Carbon Contacts in the Solid Back Transmitter," A. L. Clark; "Notes on Electrode and Diffusion Potentials," G. W. Moffitt; "The Leduc Effect in Some Metals and Alloys," Alpheus W. Smith and Alva W. Smith; "Photo-active Cells With Fluorescent Electrolytes," Geo. E. Thompson; "A Comparative Study of the Light-Sensibility of Selenium and Stibnite at 20° C. and —190° C.," D. S. Elliott; "An Extension Toward the Ultra-Violet of the Wave-Length-Sensibility Curves for Certain Crystals of Metallic Selenium," L. P. Sieg and F. C. Brown; "Note on the Induction Coil Spark," Will C. Baker.

Psychological Clinic for February; *Woodward Ave. and 36 Street, Philadelphia, Pa.; $1.50 per year, 20 cents a copy:* "Effect of Adolescent Instability on Conduct," Augusta F. Bronner; "The Binet-Simon Tests in Relation to the Factors of Experience and Maturity," J. E. Wallace Wallin; "Clinical Psychology and the Rural Schools," Ernest R. Groves.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht Aller Schulgattungen for January: *B. G. Teubner, Leipsic, Germany; 12 numbers, M. 12 per year:* "Ernst Heinrich Grimsehl, Sein Leben als Lehrer und sein Lebenswerk," Prof. Dr. W. Hillers; "Beratende Behörden, Beiräte und Ausschüsse für das Unterrichtswesen," Geh. Rat Prof. Dr. Paul Stäckel; "Das 'Meteoroskop,'" Privatdozent Dr. J. Würschmidt; "Ein Apparat zur Aufnahme des täglichen Sonnenlaufs," P. Luckey; "Notiz über einen elementarem Sutz der Mechanik," Merten; "Zur Physik der Strasse," E. Kleinen; "Tageslängen während eines Jahres für alle geographischen Breiten," V. Hevler.

Zeitschrift für den Physikalischen und Chemischen Unterricht, for January: *in Berlin W. 9, Link-Sts. 23/24; 6 numbers, $2.88 M. 12 per year:* "Ernst Grimsehl," F. Poske; "Erläuterung des Gedankenexperiments von Robert Mayer durch einen wirklichen Versuch," E. Schulze; "Demonstrationsapparate für Wechselstrom," F. Fricke; "Ein Freifallapparat," Fr. C. G. Müller; "Die einziehende Kraft einer Stromspule auf einen beweglichen Eisenkern," E. Pfeiffer; "Versuche mit ungewöhnlich starken Thermoströmen," W. Volkmann.

BOOKS RECEIVED.

Domestic Science, Books 1, 2 and 3, by Bertha E. Austin, Andrews Institute for Girls, Willoughby, O. Book 1, 239 pages; book 2, 189 pages; book 3, 330 pages. All 13x19 cm. Cloth. 1915. Lyons and Carnahan, Chicago.

Elementary Biology, by James Edward Peabody, Morris High School, New York City, and Arthur E. Hunt, Manual Training High School, Brooklyn, New York. Pages xii+194. 13x19 cm. Cloth. 1915. 65 cents. The Macmillan Co., New York City.

Education Through Play, by Henry S. Curtis, Lecturer on Recreation and Other Social Topics. Pages xix+355. 14x20 cm. Cloth. 1915. The Macmillan Co., New York City.

Optical Projection, by Simon Henry Gage and Henry Phelps Gage, Cornell University. Pages ix+731. 16x22.5 cm. Cloth. 1914. $3.00. Comstock Publishing Co., Ithaca, New York.

Marriage as the Supreme School of Life, by James J. Smith. 150 pages. 13x19 cm. Cloth. 1913. Modern Interpretations Press, Medford, Mass.

Annual Report of the Board of Regents of the Smithsonian Institution, for 1913. Pages xi+804. 15x23.5 cm. Cloth. Government Printing Office, Washington.

MICHIGAN SHOOLMASTERS' CLUB.

Mathematics Section.

Chairman—L. C. Karpinski, Ann Arbor.
Secretary—E. F. Gee, Detroit.

The meeting of the Michigan Schoolmasters' Club will be held at Ann Arbor, April 1, 2 and 3, 1915. The program of the mathematics section of the Club will consist entirely of short discussions of practical phases of the teaching of high school mathematics. On Thursday, April first, the teachers will meet at a luncheon at Newberry Hall, Ann Arbor, and the papers will be presented at the same place. The discussion on Thursday will center about the two topics: "Practical Applications of High School Mathematics," and "Correlation Between Mathematics and Other Branches and Correlation of the Various Mathematical Disciplines." Papers will be presented on the correlation between arithmetic and algebra, between algebra and geometry, and between mathematics and physics. On Friday the discussion will center about the two topics: "The Teaching of Algebra," and "The Teaching of Geometry."

BOOK REVIEWS.

Household Physics, by Alfred M. Butler, High School of Practical Arts, Boston. Pages 8-382. 13.5x19 cm. Cloth. 1914. Whitcomb and Barrows, Boston.

This is a very interesting book, and is a good deal of a departure from the ordinary texts on the subject which have recently appeared on the market. The order of presentation is somewhat different. The matter is discussed in the following order: Heat, Light, Sound, Magnetism and Electricity, Mechanics, and Plumbing. As the name of the text implies, the subject matter pertains more largely to the household side of Physics than most texts. The mathematics and formulae have been almost entirely eliminated in these discussions. It is written in an interesting and understandable way from the point of view of the pupil. There are many new cuts and half-tones of apparatus given. But the publishers have made one gross error with the cuts. Some of them are altogether too small to serve the purpose for which they were intended. It would have been much better to have given at least a page to such figures as appear on page 235, for instance. The detail is entirely lost here. We cannot but admire the practicality of the book from cover to cover. As a text for use among girls it probably will be even more than successful. Being somewhat unique in its treatment of the subject, it will undoubtedly meet with a very large sale. It is well made, the type large and clear, and most of the chapters close with a set of questions of a very practical nature.

C. H. S.

Ueber Bizentrische Polygone, Steinersche Kreis—und Kugelreihen, und die Erfindung der Inversion, by Dr. R. Bützberger, Professor an der Kantonsschule, Zürich. Pages 60. 16x24 cm. Paper, M. $1.50. 1913. B. G. Teubner, Leipsic, Germany.

The discussion of the first topic, covering thirty-two pages, opens with a brief historical account of the work done by Euler, Niklaus Fuss, C. G. J. Jakobi, and K. Hagge on this problem and others closely allied to it. Then follows a rather detailed solution of the problem for symmetrical polygons of 3, 5, 7, 9, 4, 6, 8 and 10 sides. Sixteen pages are given to the second topic, and twelve to the third; enough details are given to make it possible for a teacher of geometry to study these problems which lie a little beyond the elements of the subject.

H. E. C.

High School Geography, Physical, Economic, and Regional, by Chas. R. Dwyer, Indiana State Normal School. 536 pages. 14x21 cm. Cloth. 1914. American Book Co., Chicago.

One is pleasantly surprised in reading and studying this most recent and excellent text. It has been written by one who is thoroughly conversant with the subject, and it is written in such a manner as to cause the pupil who uses it, to think. There are 370 drawings and half-tones in the volume. The book is divided into three parts, as indicated in the heading. Parts 1 and 2 contain material enough for a course of six months in any high school, and for those schools which devote more than one semester to the subject of Physiography, Part 3 will furnish a most interesting outline of work. We have not space here to laud any of the high qualities which the book possesses. It is one of the very best of the subject which has recently been produced, and any superintendent or any Board of Education will not make a mistake if they adopt it for use in their schools. Mechanically, the book represents the highest type of the bookmaker's profession, and it will stand hard usage in the hands of the pupil. There is a complete index of 18 pages. The volume will doubtless have a wide circulation. C. H. S.

Principles and Methods in Commercial Education, by Joseph Kahn and Joseph G. Klein, College of the City of New York. Pages xiv+439. 14x20.5 cm. Cloth. 1914. $1.40. Macmillan Co., New York.

This book has attractive headings. What would you think of Perfection in Skill, How to Obtain Speed Without Sacrificing Accuracy, or the Use of the Seminar Method, in the chapter on Economics? Such captions nearly persuade one to shelve this compilation beside those other Utopian treatises which so swell these authors' sixteen formidable all-English bibliographies. However, drills for secondary schools and syllabi abound; the index is well made; chapters are summarized;

topics are selected for the student's original effort; in many paragraphs a good sentence arrests the eye. Then one reads solidly, conscious that these men are competent to advise.

They call their book a "pioneer" work "intended to give the teacher in the commercial school the broad vocational outlook . . . to the business man a sympathetic view of the work of the school . . ." As a matter-of-fact these gentlemen have provided a volume whose service is far wide of their expressed intent. It is a body of material, a text for the expectant and prospective teacher. In the first place they include an intimate apologia of schools that have long since found themselves. Again, there are presented definite grounds whence a beginner's first clash with his first class, Jason-like, causes to spring armed points at issue. Most salient is the philosophy of the authors' recurring comments contrasting the caliber of pupils fed into American schools with the demands of actual American commerce.

The pitiful relation between the work to be accomplished by and the immaturity of the high school student is treated frankly. A standard sufficiently high is advocated to indicate exclusion of the unfit as among a teacher's prime functions,—always a constructive exclusion. The German vocational system has not jogged these educators out of their common sense. A flexible course of study is recognized as a necessity for the offspring of our mixture of races. Stress is placed on the broad curriculum that permits each normal pupil to discover an aptitude. The greatest emphasis resides in the last chapter on the commercial teacher's standard of rigorous preparation for his profession.

Oblivious then to occasional flamboyancies, to the authors' avowed ignorance of their true aim, to the oracular Model Lessons, we welcome this text. We wish we could have profited by it when we began to teach. Those pages would have presented tangible divergencies, points of departure hastening our maturity. Such artificial ageing is requisite for any individual cast from the seclusion of the campus and the lethargy of office routine precipitately into the arena of the class room. A. A.

Laboratory Physics for Secondary Schools, by Robert A. Millikan and Henry G. Gale, University of Chicago, and Edward S. Bishop, School of Education, University of Chicago. Pages vi+135. 20.5x27 cm. Cloth. 1914. 50 cents. Ginn and Company, Chicago.

This new edition takes a place on the shelf a notch higher than that of 1906. It contains 60 experiments, as opposed to 51 in the earlier edition. Nine of these are variants, containing the same principle, and introduced to make possible the use of simpler or different apparatus. The book includes all the "standard experiments," with sufficient variety to adapt it to general needs. Among the noteworthy features are the experiment-record forms, the clear cuts, the clean typography and Appendix A giving by weeks the time found by these experienced teachers to be needed for a course of 40 experiments.

What we miss in this new book are some of the experiments which our teaching of the last ten years prove necessary to interest live boys and girls—Physics of the household, of the shop, and of the toy-room. The water faucet, the sewing machine, the curling iron, the vacuum-cleaner, the gas engine, the water motor, the heating costs of gas, coal, and electricity—are all objects of common interest in our home life now. While probably none of these would be asked for for college entrance, we believe them vastly more important to our boys and girls than if they were. We believe the most humanizing element of Physics lies not in the exposition of this or that law, but in the explanation of the homely or familiar phe-

nomena in the life of our students. Our laboratory guides of the future will be successful, therefore, just so far as they recognize this distinctly human view-point of our youth. T. L. H.

"The Source, Chemistry and Use of Food Products," by E. H. S. Bailey, Ph. D., Professor of Chemistry and Director, Chemical Laboratories, University of Kansas. Author of "A System of Qualitative Analysis," "Sanitary and Applied Chemistry," etc., with 75 illustrations. Pages xiv+517. 20.5x15x2.8 cm. 1914. $1.60 net. P. Blakiston's Son & Co., Philadelphia.

This book, as the preface announces, tries "to bring together in one volume of convenient size the more important facts in regard to what we eat and drink" and the author has succeeded to a remarkable degree in doing what he set out to do. The book contains a vast amount of information much of which should be in the possession of every housewife. "The plan followed in treating of the important foods and beverages found in the markets of the world, is to discuss their source, methods of preparation for the market, how they are packed, preserved and shipped, their composition and nutrient and dietetic value, and their use by people of different countries."

The book is intended as a text for students of foods in high schools and colleges.

The economic side of the subject is well handled, for example the cost per pound of each of a large number of cereal preparations is compared with the cost of the raw material and the cost per bushel of the grain itself is compared with the cost per bushel as made up into the various breakfast foods.

The analysis of both the raw grain and of each of the prepared products is then given showing in most cases a smaller food value in the

much more costly prepared food than in the raw material. The degree to which the prepared state of the material counterbalances the greater cost is considered and the effect of preparation on digestibility is considered together with the question of the undesirability of using predigested foods when in health.

Many interesting processes are described such for example as that by which macaroni is made. The modern methods in use in making oleomargarine and in hardening fats by hydrogenation are given together with much interesting material in regard to the increasing importance of cotton seed oil and its many uses.

The making and baking of bread is scientifically treated as it also jelly making and many other processes of the home. Milk and milk products receive much attention as do meats and meat products. The chapter on nuts and nut products is especially interesting and timely.

In the reviewer's opinion the book would make an excellent reference book for every high school library and an excellent text for college students who have some general chemistry and a little organic chemistry, and who wish to specialize in domestic science. It would also be a fine addition to the private library of every housewife. F. B. W.

Essentials of College Botany, by Charles E. Bessey and Ernest A. Bessey. xiv+409 pages. 13x19 cm. 1914. Henry Holt & Co.

This is the eighth edition of the author's standard text, the first edition of which appeared thirty-five years ago. The present book has been entirely rewritten, and therefore differs markedly from earlier editioss.

The first five chapters, comprising about one third of the book, are given up to the morphology of cells and tissues, and to plant physiology. The inclusion of a chapter on the "Chemistry of Plants" leads one to expect a general survey of the subject; in fact there is nothing but a tabulation of chemical compounds known to occur in plants, with the place and manner of occurrence. The tabulation will be valuable for reference, but one is at a loss to know just what use a student would make of it as part of a textbook.

The latter two-thirds of the book take up the phyla of the plant kingdom in evolutionary order. It is to be noted that the authors make fourteen phyla in place of the familiar four divisions.

There are few illustrations and these are all drawings. The analysis phyla and their divisions, together with two diagrams showing relationships, occupy the entire closing chapter and are a valuable feature.

In addition to its evident usefulness as a college text, the book will be valuable to the high school teacher and pupil for reference and collateral reading. W. L. E.

The Teaching of Biology in the Secondary School, by F. E. Lloyd and M. A. Bigelow. viii+491 pages. 14x20 cm. $1.50. 1914. Longman, Green & Co.

Announced as a new edition of the well known work by these authors. However, the changes are few, the book having apparently been reprinted from the plates that were used for the earlier editions. In the zoölogical part a short note is added to each chapter, bringing it up to date as far as the limited space would allow. The preface does not mention any changes in the botanical section, and none were discoverable other than the addition of some titles to the bibliography in the chapter on "Botanical Literature." The magazine list has not been corrected to date. School Science is given as published at Ravenswood, and no place of publication is given for Nature Study (Nature Study Review?).

W. L. E.